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# Engineering and Mining Journal

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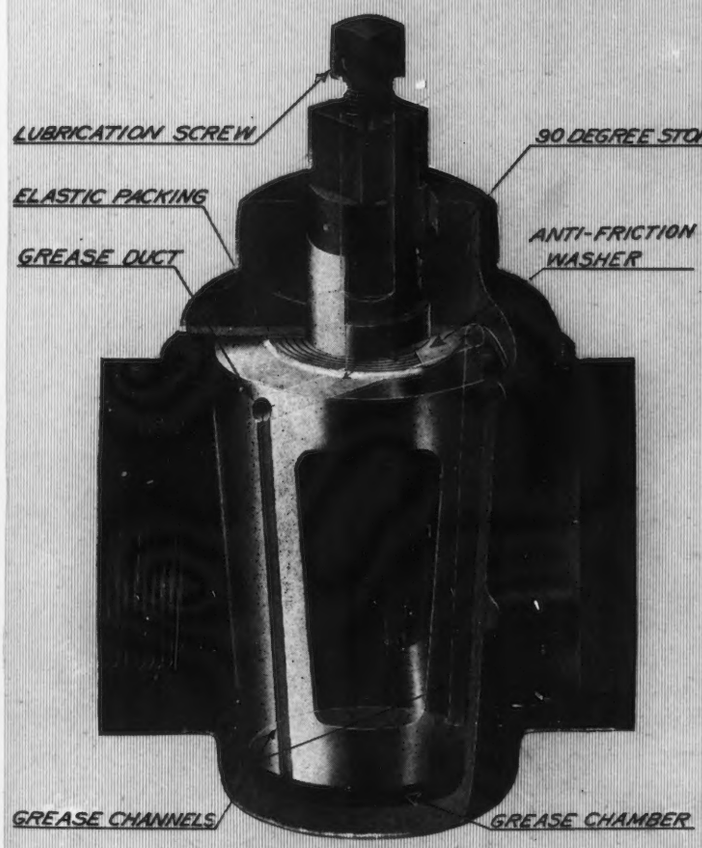


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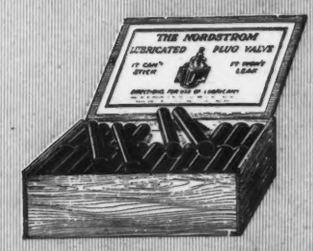


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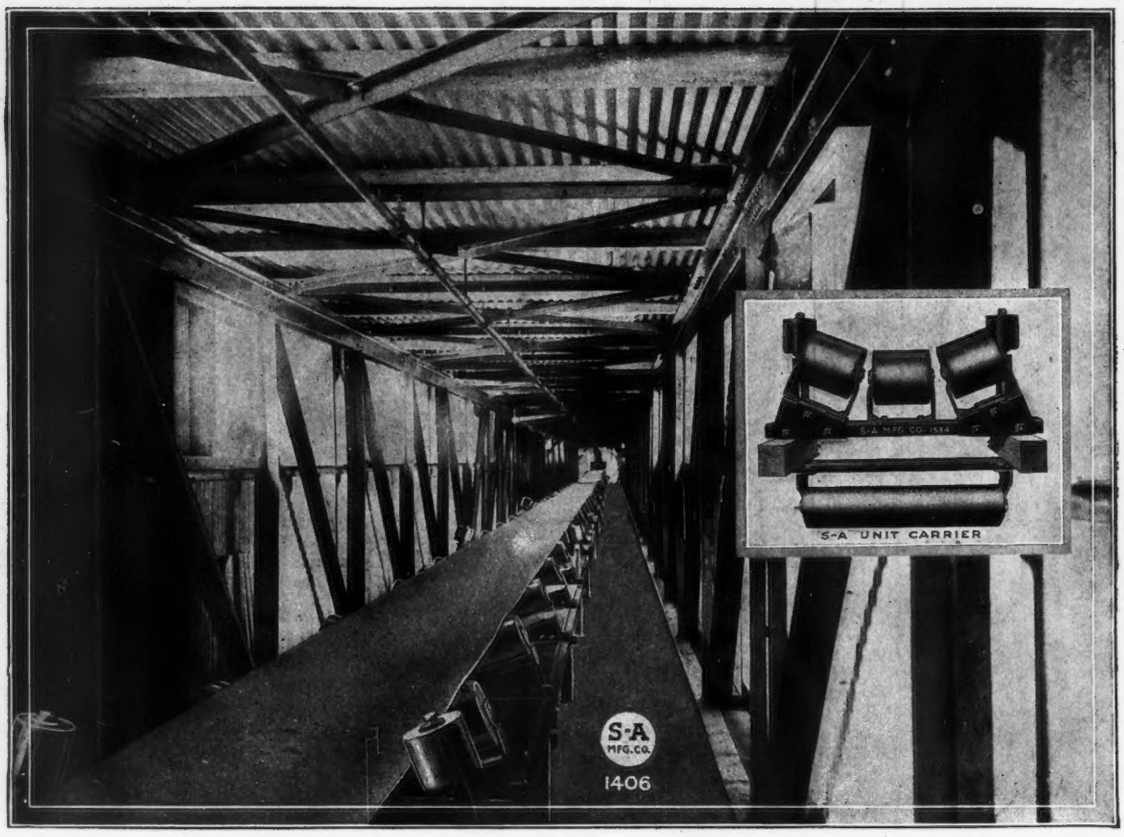


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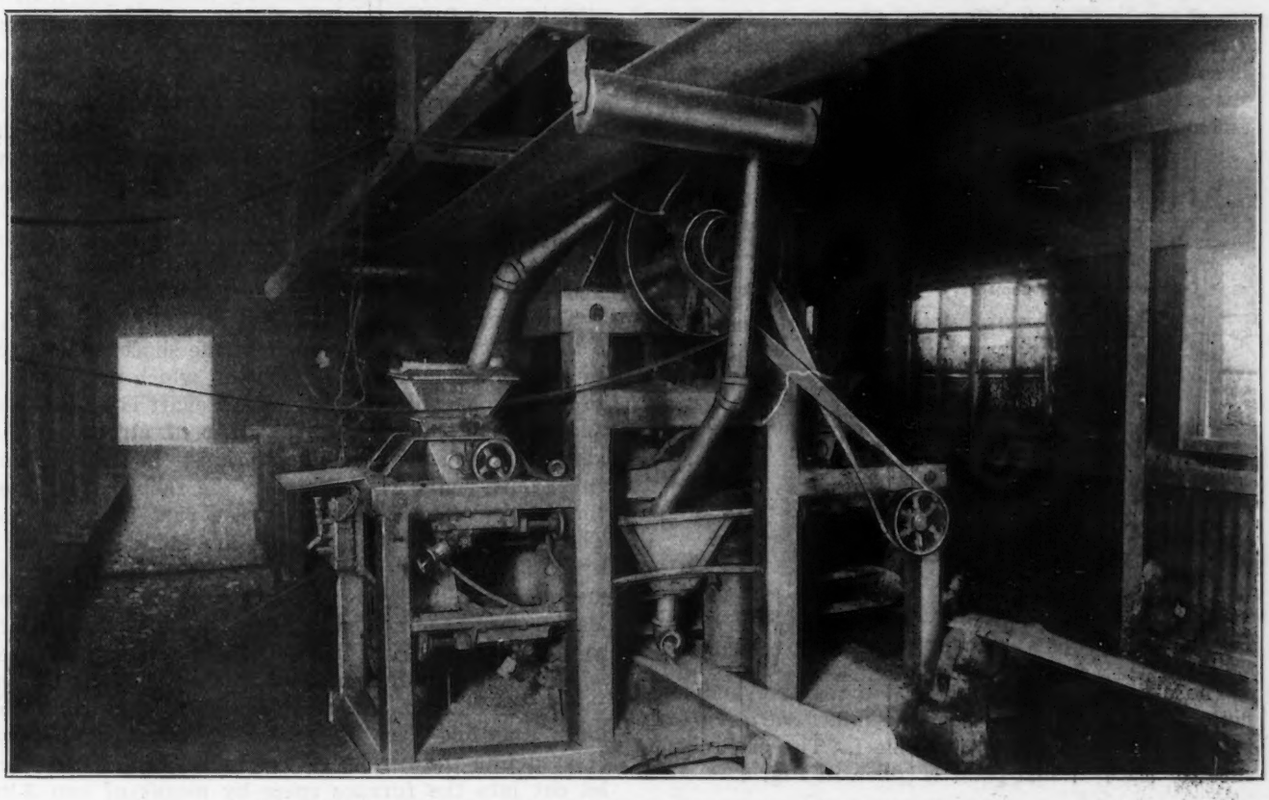


HIGH-INTENSITY MACHINE USED FOR CLEANING ZINC CONCENTRATES

# The Roasting and Magnetic Separation Of Wisconsin Zinc Ores


BY E. G. DEUTMAN*



*The advisability of a thorough cleaning of concentrates or other mill products, with the objective of marketing the concentrates to better advantage, or of reducing freight rates by the elimination of non-valuable material, merits the attention of the mill operator. A high degree of success has attended the separation of iron compounds from sphalerite or blende by a preliminary roast and the use of magnetic separators. The paper presents a concise description of a plant in the Wisconsin zinc field which is successfully handling zinc concentrates high in iron and which has been developed from practice.*


IN THE Wisconsin field, the zinc blende is usually found associated with iron sulphide in the form of marcasite. This ore, after being concentrated at the mines, is sent to separating plants for further treatment by roasting and magnetic separation, inasmuch as the mixed blende and marcasite concentrate, owing to its high iron content, is not suitable for the zinc smelter.

Most of the roasting and magnetic separating are done by three companies, the Mineral Point Zinc Co., at Mineral Point; the National Zinc Separating Co., at Cuba City, and the Wisconsin Zinc Co., at New Diggings. There are other roasting and separating plants in the district—the Linden Zinc Co., at Linden, which company also has a plant at Cuba City; the Benton Roaster, at Benton, and the Mulcahy Roaster, at Shullsburg, operated by the Oliver Iron Mining Co. Each of the largest three plants has a capacity of 275 tons of ore


*Superintendent, National Zinc Separating Co., Cuba City, Wisconsin.

per 24 hours, and their combined capacity can easily take care of the bulk of the Wisconsin zinc-field production.

The method of roasting ore at all of these plants is practically the same, inasmuch as each has a self-roasting seven-hearth furnace. The National plant uses a Wedge furnace, whereas the plants at Mineral Point and New Diggings have Skinner installations manufactured by the Western Chemical Manufacturing Co., of Denver, Colo. The treatment of the ores at the plants is so similar that the description given here in detail of the method used at the National plant, with which I am most familiar, will answer for all.

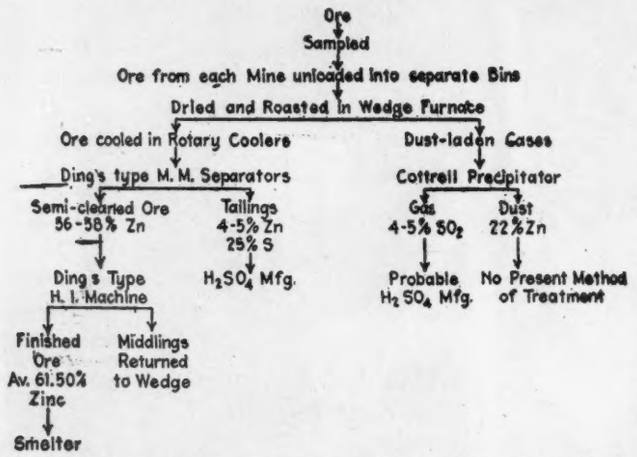



FIG. 1. FLOW-SHEET OF NATIONAL ZINC SEPARATING CO.'S PLANT

The ore as it is received at the roasting and magnetic separating plants from the mines varies greatly in composition, as shown in Table I. The general flow sheet of the National plant is given in Fig. 1.

TABLE I. COMPOSITION OF CONCENTRATES SENT TO SEPARATING PLANTS

| Mine | Zinc, Per Cent. | Iron, Per Cent. | Lead, Per Cent. | Lime, Per Cent. | Sulphur Per Cent |
|---|---|---|---|---|---|
| Dewdall | 21.60 | 27.40 | 0.82 | 2.15 | 41.60 |
| Martin | 39.95 | 17.12 | 0.20 | 1.67 | 38.30 |
| Jefferson | 45.90 | 12.85 | 0.22 | 1.50 | 35.73 |

The ore is shipped to the National plant from the various mines of the district, which lie from a few miles to a distance of 25 miles. Shipments are made almost exclusively in box cars, although, in a few instances, where the mines are close to the plant, trucks and teams are used. As the National plant receives all of its ore in box cars, and also ships its finished products out in box cars, efforts are made to insure a maximum unloading and loading tonnage. The box cars are first set out with the side door opposite the green-ore storage elevator. The ore is then dragged out of the cars by means of a Clark single unloading shovel into the underground boot of the elevator, which, in turn, carries the ore to the top of the storage bins, where it is distributed into separate bins by means of a belt conveyor and an automatic tripper. A large tonnage can be handled by this method. Three men can unload at the rate of one ton per minute, which includes the time of weighing the cars in and out. In loading the finished ore, the ore is spouted from the finished-ore bins, which are immediately above the green-ore bins, into the side of the car, where it is stacked in the ends of the car by means of a portable belt conveyor.

The sampling of the cars as they are received is done by means of a green-ore gun, which consists of a 2-in. pipe about 3 ft. long. The roasted ore is sampled with a slotted gun, which consists of a 1-in. pipe 4 ft. long, with 1 x $\frac{3}{8}$ in. slots 1 in. apart lengthwise on the pipe. The pipe is covered with a sheath when poked into the bed of ore. The sheath is pulled off when the gun is in position, allowing the ore to fall into the slots. As these methods of sampling are more or less standard in other districts, no further details will be given here.

### Roasting Furnace

The roasting is done in a Wedge mechanical furnace, which has seven roasting hearths and a top drying hearth and is 22 ft. 6 in. in diameter and 24 ft. above the floor. The furnace consists of a cylindrical steel riveted shell incasing walls of red brick. The hearths are constructed of specially shaped fire brick and are made horizontal, each hearth, however, forming an arch above the one below.

The central shaft is made of riveted steel plate, being 5 ft. in diameter. The outside of the shaft is protected by special insulation and fire brick, which are attached to and revolve with it. The hollow shaft is open at top and bottom, and the natural draft of air through it keeps it sufficiently cool for workmen to enter at any time, thus giving free access to the rabble arms from the inside. The rabble arms are cast in one piece. They weigh 1200 lb. each, and are made hollow with a web horizontally through the center. The rear end is machined and fitted with pipes for air cooling, one pipe leading from the air manifold at the top of the shaft to the upper side of the median web, and the other leading to a manifold at the bottom of the shaft from the lower side of the median web. It is from the lower manifold that the heated air can be either increased into the furnace through the lower hearth, or let out into the furnace space by means of two 3-in. bleeder valves, depending on the condition of the roast. The rabble blades are fitted on the arms with rabble blade holders.

The ore is brought by a belt conveyor and elevator to two feeding hoppers at the top of the kiln, where it is fed to the kiln by two arms revolving at the rate of 90 sec. per revolution. These arms can be lengthened or shortened, depending on the desired tonnage to be fed. As the ore drops on the kiln it is stirred by the rabbles and gradually worked to the central shaft and there falls onto the first hearth; here the rabbles gradually work it outward in a spiral path to the periphery, where it falls onto the second hearth. On the first, third, fifth, and seventh hearths, the ore travels radially outward, and on the second, fourth, and sixth hearths it travels in the opposite direction. The roasted ore is discharged from the periphery of the lowest hearth into two rotary coolers.

With this type of furnace no outside fuel is necessary, as the ore is roasted by its own heat of combustion, the ore being heated up gradually on its downward passage in the furnace until it reaches the seventh hearth, where the maximum heat of about 900 to 1000° F. is reached. By maintaining this temperature with varying feed, 4 to 5% sulphur-dioxide gas, suitable for sulphuric-acid manufacture, is evolved, and tailings averaging 25% sulphur, suitable for further roasting for manufacturing sulphuric acid, are recovered from the magnetic separators. If the temperature becomes too high, the valves on the lower manifold are opened,

and the air is allowed to escape into the furnace space, and if more heat is desired these valves are closed.

With this type of roasting furnace, the marcasite ($FeS_2$) in the ore receives a strong oxidizing roast, though the heat maintained is not sufficient to oxidize any of the blende. The marcasite particles are converted on the outside to the magnetic oxide of iron ($Fe_3O_4$), the cores of the particles remaining $Fe_nS_{n+1}$ and, to some extent, unaltered $FeS_2$. During the roasting and separating, the lead and lime (CaO) content will also vary from the green to the finished ore.

The lead increases about 0.015% for every 0.1% contained in the ore. The lime (CaO), on the other hand, decreases about 0.012% for every 0.1% contained therein. This decrease is due to the fact that in the process of roasting partial decrepitation of the ore takes place, and the CaO, being lighter in gravity, has greater tendency to be carried in the flue dust than does the ore itself. Screen analyses before and after roasting are given in Table II.

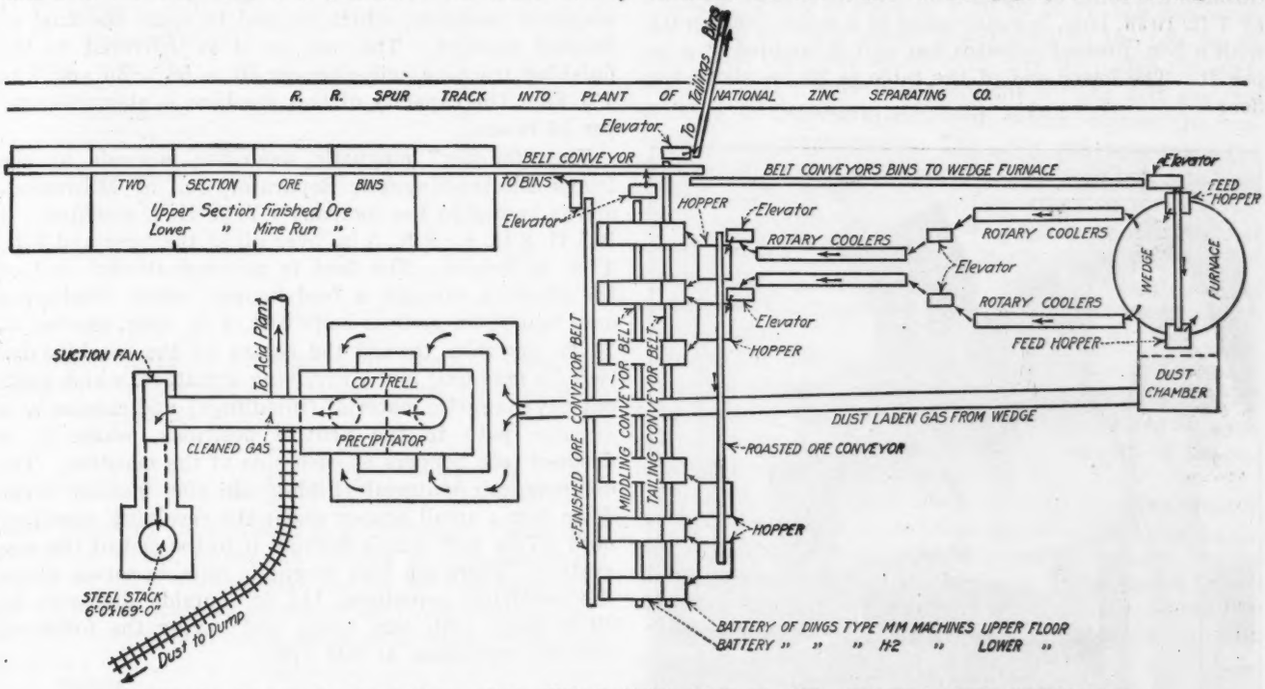



FIG. 2. PLAN OF NATIONAL ZINC SEPARATING CO.'S PLANT AT CUBA CITY, WISCONSIN

TABLE II. SCREEN ANALYSES BEFORE AND AFTER ROAST TREATMENT

| Size: | Before, Per Cent. | After, Per Cent. |
|---|---|---|
| On ½-in. mesh | 0.20 | 0.10 |
| On ¼-in. mesh | 21.70 | 9.70 |
| On 10-in. mesh | 17.90 | 7.80 |
| On 20-in. mesh | 28.10 | 23.30 |
| On 40-in. mesh | 22.90 | 29.10 |
| Through 40-in. mesh | 9.20 | 30.00 |

The dust-laden gases pass out through the side of the furnace from the first hearth, being first led into a dust chamber, and then through a Cottrell precipitator, and are then discharged to the air through a stack 6 ft. in diameter and 170 ft. high.

The Cottrell precipitator consists of two units which are so arranged that either unit may be operated alone or in parallel with the other. At present each unit is being operated separately and alternately for periods of about two weeks. The precipitator is handling about 9000 cu.ft. of gas per min. at 290° F. and at a velocity of about 6 ft. per sec. The combined capacity is 18,000 cu.ft., per min. for the two units when operated in parallel.

Each unit is 9 ft. by 13 ft. 6 in. from the center line to center line of column supports, and has an over-all height from ground level to base of stack of 34 ft. 8 in. The dust-laden gases enter near the top of the bottom header from opposite sides. The gases flow around the pipes that extend 5 ft. into the bottom header and tend to heat these pipes equally. This causes the pipes to draw equally, and as a result an equal amount of gas tends to pass up through the pipes and is discharged at the top of the precipitator. The fines are collected on the walls of the pipes, or collecting electrodes, whence they drop or are shaken down into the receiving hopper at the bottom. The gases pass on upward into the gas-collecting headers at the top and then down through a suction fan into the steel stack.

The collecting electrodes, of which there are 36 in each unit, are pipes 12 in. inside diameter by 15 ft. long, made of No. 14 sheet steel. The high-tension current used in connection with the Cottrell is converted from 220 to 240 volts a. c. The electrical apparatus consists of a transformer, a switch board, a synchronous motor, and a mechanical rectifier. The rectified current used in connection with the precipitator is about 65,000 each unit, are pipes 12 in. inside diameter by 15 ft. long, made of No. 14 gage sheet steel. The high-tension current is transmitted to the precipitator by a line passing through the top of the electrical building to the caged housing at the top of the precipitator.

The dust recovered is about 95 to 97% of the total amount lost in the gases, and will approximate about 1.6% of the amount of ore roasted.

From the Wedge furnace the ore passes through four rotary cooling drums, revolving at 6 r.p.m. They are each 2 ft. inside diameter and 26 ft. long, and are made of $\frac{5}{16}$-in. riveted plate steel. The drums are water-cooled by means of a spray directly above them. No attempt is made to cool the ore completely, so that it is absolutely cold, as it has been found that roasted

ore is not as magnetic when cold as when slightly warm to the hand. Each cooler requires about 30 gal. of water per min. to cool the ore to the proper temperature.

After cooling, the ore is ready for magnetic separation. It first passes over a rougher separator of the Dings Type M. M. machine. This machine occupies a floor space of about 4 x 10 ft. and has an extreme height of 83 in. The ore is received in a hopper at the upper end of the machine, which feeds it in an evenly regulated flow onto a vibrating conveyor or shaking table, actuated by two eccentrics on the driving shaft rotating at 450 r.p.m., causing the ore to travel through the zones of separation. The table is 21 in. wide by 7 ft. 10 in. long, is constructed of a maple framework with a ¼-in. pressed asbestos top, and is inclined at 4 in. per ft. The lower end of the table is 20 in. above the floor.

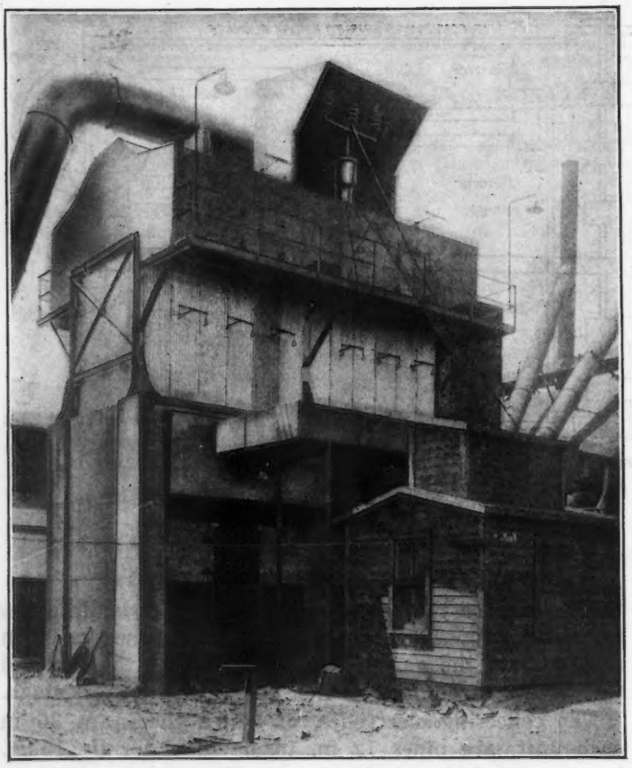


FIG. 3. COTTRELL PRECIPITATOR HIGH-INTENSITY SEPARATOR

Above the tables are two sets of magnets placed in the same inclined position as the table. The first set, or rougher pair, are 5½ in. outside diameter by 20½ in. long and have a maximum current strength of about 2 amp. at 225 volts when heated to 100° F. The second pair, or semi-finisher coils, are 8⅞ in. outside diameter by 19 in. long, having a maximum current strength of about 3 amp. when heated to 100° F. Under each pair of magnets are revolving bronze spiders 26 in. in diameter with 32 laminated electric steel secondary magnets set in the rims of the spiders about 1½ in. apart and held in place by brass keepers. The upper parts of these secondary magnets are U-shaped and are inductively energized by the lip of the pole pieces of the stationary magnets immediately above, which they embrace while over the conveyor. This close contact presents a large area of surface between the primary and secondary magnets, and reduces the magnetic resistance at this point to a minimum. The lower parts of these secondary magnets are set from ⅜ to ½ in. above the top of the asbestos table.

The magnetic iron sulphide, as it is picked out of the ore traveling down the table, is carried on a circular path out of the magnetic circuit to the neutral positions where the spider rims hang over the conveyor, and is dropped into hoppers made of non-magnetic sheet metal. It is then delivered by belt conveyor and elevator to a storage bin. The tailing or magnetic product thus made averages about 25% sulphur and 4 to 5% Zn. The semi-finished ore passes over the end of the table and down into a Dings separator of higher magnetic intensity, which is used to make the final or finished product. The ore, as it is delivered to the finishing machine, will average 56 to 58% Zn and 3 to 4% Fe. The capacity of this machine is about 60 tons per 24 hours.

The "finisher" magnetic separator is made by the Dings Electro-Magnetic Separator Co., of Milwaukee, and is known as the company's Type H. I. machine. It is 5 ft. 8 in. by 8 ft. 5 in. over all at the base and 7 ft. 4 in. in height. The feed is received at each end of the machine through a feed hopper, which discharges onto two 12-in. endless belts 6 ft. 8 in. long, moving at 70 ft. per min. toward the center of the machine between a magnetic and a revolving armature, which picks out any magnetic material (middlings) and carries it in circular path to the neutral positions, where it is dropped into hoppers at each side of the machine. The non-magnetic material (high-grade zinc blende) drops down into a small hopper under the revolving armature onto a 7-in. belt, which delivers it to the end of the separators. There are four magnetic coils, in series, under the revolving armature, 11½ in. outside diameter by 20 in. long, with 6-in. cores, and having the following current regulation at 225 volts:

| | Amperes |
|---|---|
| Maximum current hot (100° F.) | 15 |
| Maximum current cold | 19 |
| Minimum current hot (100° F.) | 7½ |
| Minimum current cold | 9 |

The armature which completes the magnetic field is made of solid steel, being 24 in. in diameter by 6 in. wide on a vertical shaft setting about ¾ in. to ⅞ in. above the pole pieces of the magnets. The weight of this armature and the downward pull are taken care of by a ball thrust bearing.

The capacity of this machine is from 40 to 45 tons per 24 hours.

## POWER

The power is furnished by the Interstate Light and Power Co. of Galena, Ill., which place is 14 miles from Cuba City, Wis. It is transmitted to the National plant from the Cuba City substation by a 4000-volt a. c. service line. It is here transformed to 220- to 240-volt current. The direct current is made with a 100-hp. Westinghouse induction motor direct-connected to a 70-kw. Westinghouse generator. The power consump-

TABLE III. KILOWATT-HOURS REQUIRED FOR 24-HOUR SERVICE

| | Kilowatt-Hours per 24 Hours |
|---|---|
| Wedge furnace | 315.00 |
| Coolers, elevators, separators | 655.00 |
| Cottrell and stack fan | 550.00 |
| D.c. generator | 855.00 |
| Loading and unloading ore | 250.00 |
| Lights | 175.00 |
| Water for coolers | 150.00 |
| Total daily consumption | 2,950.00 |

tion per 24 hours required for the treatment of 125 tons of ore per day is given in Table III.

COSTS PER TON OF GREEN ORE ROASTED, BASED ON A TONNAGE OF 125 TONS PER 24 HOURS

| | | |
|---|---|---|
| Roasting and separating: | | |
| Labor | $0.70 | |
| Power | .43 | |
| Repairs and supplies | .15 | |
| Total | | $1.28 |
| Ore receiving and shipping: | | |
| Labor | $0.18 | |
| Ore freight | .50 | |
| Power | .05 | |
| Repairs and supplies | .06 | |
| Assaying | .12 | |
| Total | | .91 |
| Cottrell electric precipitator: | | |
| Labor | 0.06 | |
| Power | .11 | |
| Repairs and supplies | .01 | |
| Total | | .18 |
| General: | | |
| Overhead | 0.25 | |
| Office expense | .20 | |
| Insurance, taxes, etc | .01 | |
| Workmen's compensation insurance | .01 | |
| Freight and express | .03 | |
| Experimental | .03 | |
| Labor | .06 | |
| Repairs and supplies | .04 | |
| Total | | .63 |
| Total cost | | $3.00 |

### Costs

The accompanying table gives, in itemized form, the costs per ton of green ore roasted, based on a tonnage of 125 tons per 24 hours.

## Accidents in Reduction Works

The following table, taken from Technical Paper 215, Bureau of Mines, shows the number of men employed, number of days worked, and number of men killed and injured in ore-dressing plants in the United States during 1917, comparison being made with related statistics for 1916:

ACCIDENT STATISTICS, ORE-DRESSING PLANTS

| State | Men Employed | Days of Labor Performed | Average Days Active | Killed | Injured |
|---|---|---|---|---|---|
| Alabama | 193 | 44,715 | 232 | 1 | 7 |
| Alaska | 467 | 139,960 | 300 | 3 | 141 |
| Arizona | 2,630 | 803,567 | 306 | 6 | 578 |
| Arkansas | 163 | 38,343 | 235 | .. | 11 |
| California | 755 | 271,800 | 360 | .. | 30 |
| Colorado | 1,715 | 514,500 | 300 | 7 | 214 |
| Georgia | 82 | 24,769 | 302 | .. | 1 |
| Idaho | 642 | 179,238 | 279 | .. | 62 |
| Illinois | 156 | 43,008 | 276 | .. | 9 |
| Kansas | 206 | 32,190 | 156 | .. | 15 |
| Maryland | 26 | 5,432 | 209 | .. | ... |
| Michigan | 2,426 | 752,874 | 310 | 2 | 88 |
| Minnesota | 337 | 80,703 | 239 | .. | 40 |
| Missouri | 1,523 | 392,225 | 258 | 2 | 175 |
| Montana | 2,051 | 605,705 | 295 | 6 | 148 |
| Nevada | 1,565 | 486,255 | 311 | 4 | 117 |
| New Jersey | 537 | 165,308 | 308 | 2 | 257 |
| New Mexico | 891 | 290,846 | 326 | 1 | 183 |
| New York | 565 | 156,601 | 277 | 1 | 77 |
| North Carolina | 46 | 11,285 | 245 | .. | 14 |
| Oklahoma | 452 | 103,933 | 230 | 2 | 208 |
| Oregon | 97 | 23,637 | 244 | .. | 6 |
| Pennsylvania | 24 | 5,165 | 215 | .. | 1 |
| South Dakota | 250 | 87,475 | 350 | .. | 23 |
| Tennessee | 425 | 114,513 | 269 | 1 | 40 |
| Texas | 100 | 29,330 | 293 | .. | 6 |
| Utah | 4,103 | 1,459,383 | 356 | 5 | 496 |
| Vermont | 215 | 58,308 | 271 | .. | 13 |
| Virginia | 709 | 206,921 | 292 | .. | 16 |
| Wash.ngton | 63 | 11,800 | 187 | .. | 8 |
| West Virginia | ... | ... | ... | ... | ... |
| Wisconsin | 247 | 64,011 | 259 | 3 | 150 |
| Other States | 450 | 107,699 | 239 | 1 | 18 |
| Total, 1917 | 24,111 | 7,311,499 | 303 | 47 | 2,952 |
| Total, 1916 | 22,365 | 7,041,083 | 315 | 33 | 3,184 |

The figures relating to California were supplied by the Industrial Accident Commission of the State of California. Those relating to Colorado were supplied by Fred Carroll, the Commissioner of Mines, Denver, Colorado.

## Sorting and Washing Plant for Magnesite Ore*

The plant at the Hemet Magnesite mine, situated seven miles southwest of Hemet, Riverside County, Calif., was one of the few properties operating at full capacity after the almost complete shutdown which occurred recently in the magnesite-mining industry in California and Washington. Operations have been greatly curtailed within the last few weeks. A grade of magnesite is produced which is in great demand for plastic purposes.

Hand sorting is done on a 30 by 50 ft. belt conveyor, the material being evenly distributed on the belt by an 18-in. belt conveyor which runs directly under the sorting belt. The rejections from the sorting belt are run directly to the waste conveyor, which carries the material to the waste dump. The 12-in. conveyor takes the magnesite from the sorting plant to a Gilbert washing screen, where it is washed before going to the ore bin. The water after screening the magnesite is run to a Dorr thickener, where the solids are settled out and the clear water is again used. From the ore bin at the washer the magnesite is carried to the mill by a gravity surface tram.

From the 300-ton mill ore bin, the ore is fed to a Wheeling crusher, set at 1-in. opening. The material after passing the crusher is elevated to the feeder supplying the kiln, which is of the rotary type 6 by 60 ft., making one revolution per minute.

It takes the material about 45 min. to pass through the kiln, and at the end of the calcination the magnesite is a deep cherry red. After calcining, the material is discharged on a steel conveyor, which distributes it on the cooling floor.

Magnesite is hard to grind, and, even when cool, will cause the grinding mills to heat badly; hence the necessity of cooling the material after calcination.

From the cooling floor the material is passed over a magnetic separator to take out any iron before going to the grinders. The grinding is done in two stages. The coarse grinder is a steel plate mill which takes the 1-in. material and crushes it to about eight mesh. The fine crushers used are Sturtevant emery mills, which take the material at eight mesh and make 98% pass 100 mesh in one operation. From the grinders the material is elevated to the bin which supplies the packing department, where the material is all packed in barrels for shipment.

The whole plant is operated by electric power furnished from the lines of the Southern Sierra Power Co. All machinery and electrical equipment were furnished by Collins & Webb, Inc., of Los Angeles.

**Zinc Production in Germany**, according to the *Deutsche Allgemeine Zeitung* (republished in *Journ. Soc. Chem. Ind.*, Apr. 30, 1919), was approximately 280,000 metric tons during 1918. Imports were about 56,000 metric tons and exports were 105,000 metric tons. In 1913, Germany smelted 260,000 tons of foreign zinc ore and 541,000 tons of home ore, yielding 103,000 and 175,000 tons of zinc, respectively. At present, the home zinc production exceeds the demand, and, although the latter will increase after the signing of peace, there will be no immediate necessity of importing zinc ore or the finished material.

*Abstracted from *Mining and Oil Bulletin*, March, 1919.

# Notes on Screening Practice

BY JOHN BLAND*

*A detailed analysis of the factors affecting the passage of grains of certain shapes and sizes through the apertures of a vibratory or stationary screen. Square-mesh and long-mesh screening are discussed, and the various methods of screen sizing in practice are described and classified. Examples of normal practice at a number of plants are also given. A description of cloth screening will be found of value to many engineers who have as yet not recognized the utility of non-metallic material for this purpose. A number of suggestive arguments are advanced in connection with screening practice and equipment.*

"DIFFICULT" grains have been defined as those portions of the true undersize of a crushed ore which, in diameter, are nearest in size to the screen opening, but which fail to pass through the sieve. Grains have three diameters and differ from each other in shape rather than in size.

The various shapes of grains may be divided into three classes: (1) Those of three dimensions less than the square-mesh opening—cubical and roundish grains; (2) of two dimensions less and one greater than the square-mesh opening—conical, cylindrical, grains 20% narrower than the opening but 15% (and more) longer than the opening; (3) those of two dimensions greater and one dimension less than the square-mesh opening—tabular grains.

## Square-Mesh and Long-Mesh Screening

On square-mesh screening, the cubical and long grains are true undersize; on long mesh, all three classes are undersize; on square mesh, long grains only are "difficult"; on long mesh, tabular grains only are "difficult" to pass the aperture. The actual difference in character of undersize from the two meshes is inclusion of all cubical and some of the long grains through square mesh, as contrasted with inclusion of all of the cubical, all of the long, and some of the tabular grains through long mesh. The inclusion of tabular grains in undersize, along with cubical and long grains of far less mass, has a peculiar and an important place in both closed-circuit crushing and screen classification of sands before concentration—practically the whole ore-dressing fields; for there are few important gangue minerals which return a high proportion of tabular grains in crushing, although there are many concentrate grains which do so.

In making the difficult separation of wolframite (magnetic) from cassiterite (non-magnetic), efficiency depends on forming a minimum of grains below 1/3000 in. in size which are practically inseparable. In crushing through, say, 16 mesh, 30 to 60% of the wolframite will break into pieces five times as wide and long as they are thick. The average of the larger particles passing to undersize through long mesh will be five times as long, wide, and thick, or 125 times the mass, as compared to the same grains through the same opening width with square mesh. Quartz is of practically the same mass through either. Of course this represents hardly more than 20% of the total wolframite, and the actual approach in practice to this theoretical condition depends on close or complete screening, which is practically unknown in ore dressing. On a typical Portuguese mixed wolfram and tin ore, the percentage of $WO_3$ passing 1/2000-in. opening (electroplated 200-mesh screen cloth), after crushing through 1-mm. opening on long mesh, was only 22% of the amount of the same-sized grains that were obtained after crushing through 1-mm. square mesh.

## The Classification of Mica Mineral

As to table concentration, middlings are usually made up of a considerable proportion of flat grains, and these grains would have reported with gangue of but 1/20 to 1/125 of the mass had the mill feed been classified through long mesh. This classification enables one to arrive at a solution of the difficult problem of separating wolframite from garnets, detaining the high-grade concentrate required and insuring a high recovery at the same time.

The important exception to this empirical rule of long-mesh classifying of the greater mass of concentrate grain with smaller gangue is found in the recovery of mica. This suggests separation of mica in a clean product by screening only. At the Rare Minerals Co.'s mill at Custer, S. D., this is done in making roofing mica as a byproduct in the production of tin concentrate. Closed-circuit crushing through long mesh (punched plate) $1\frac{1}{8}$ x $\frac{1}{8}$ in. for preliminary jigging delivers the undersize to square-mesh (wire cloth) $\frac{1}{4}$ x $\frac{1}{4}$ in. All quartz, feldspar, and cassiterite passing the $1\frac{1}{8}$ x $\frac{1}{8}$ in. opening will also pass the $\frac{1}{4}$ x $\frac{1}{4}$ in. opening, whereas mica "flakes" greater than $\frac{1}{4}$ in. in breadth appear as a clean oversize. Undersize passes to long mesh $\frac{1}{8}$ x 1/30 in., its undersize again to 1/20 x 1/20 in., from which mica is again taken as clean oversize. Oversize from $\frac{1}{8}$ x 1/30 in. includes the true oversize through $\frac{1}{8}$ x 1/30 in., for jigging; the undersize from 1/20 x 1/20 in. is further screen classified for tabling. Eighty per cent. of the mica content of the ore, a high percentage, is thus diverted for separate grinding for roofing mica, which, at the "normal" price of $38 per ton, is a considerable item.

This method of separation is applicable to graphite and other minerals. It was in working out this flow sheet that the comparative advantages of long mesh were suggested. Long mesh makes practicable higher capacity and incomparably more accurate screening in the average operator's hands.

## Systems of Screen Sizing

There are, essentially, two systems of screen arrangement for grading into multiple divisions. First, superimposed screens, the coarsest, as the top deck, grading to the finest, at the bottom deck. Here the coarsest sizes are removed first, as oversize, the undersize dropping to the screen below to feed it. The second method is peculiarly distinct. All screens are in a single plane or deck, the feed reaching the finest screen first, the sizes being removed as undersize, and the oversize prod-

*Mining engineer, Englewood, South Dakota.

ucts moving forward to feed the successive screens. The coarsest size is removed last.

The second method is the one in use, for example, at the Carborundum Co.'s plant at Niagara Falls, N. Y., where accurate grading is essential. The first method has the advantage of slightly less screen-cloth wear, but chiefly in floor-space economy. On the other hand, screening in this system is usually inaccurate or incomplete. Strangely enough, though each system has its supporters, the underlying principle involved remains unascertained.

No attention is paid here to a possible third system, where screens are superimposed but staggered, zigzagged, end to end, forming a high, awkward, inaccessible and mechanically impossible arrangement for an actuated screen. Thomas A. Edison employed this system in his screen, which was, however, inert and not actuated.

### The Problem of "Difficult" Grains

The principle applied in selecting a proper combination of the two systems involves action of the "difficult" grains. The reader is hereby warned. Obviously, minus 200-mesh grains will pass a 16-mesh screen instantly. The extended screen cloth length is used to insure the passage of the "difficult" grains. Where ordinary grains drop to the screen below in the first, or superimposed, system, "difficult" grains pass over but a fraction of the lower screen. If these grains are true oversize on this screen, well and good; but if some of them are true undersize, they have only a part of their screen length to traverse, and they are the grains which must have the full screen length to insure passage. For they were "difficult" grains on the screen above and will be more "difficult" on the screen below, which has smaller apertures.

Under conditions in which the difference in successive screen openings is so small that the "difficult" grains on any screen will be true undersize on the next smaller screen opening, screens may not be superimposed. For example, such differences as between 30 and 60 mesh may be too small on some materials, but great enough on others, depending on the amount of "difficult" (long) grains present. Briefly, screens may be superimposed where the "difficult" grains are true oversize on the next smaller screen opening.

### Modern Screen Stratifies Pulp Bed

The second method calls for a screen machine as many times longer than the machine for the first method as there are screen sizes. A combination of the two methods should embody the compactness of the first with the accuracy of the second. This may be done in varying degrees, depending on closeness of sizes and character of material. The presumption that the second method is objectionable because of deep pulp bed on all screens is not important, because the modern vibratory screen stratifies any depth of pulp bed instantly, offering unobstructed opportunity for passage of undersize. In combining the two systems, the "difficult" grains on each screen are selected. This may be done by incomplete screening or by taking those grains passing last and with difficulty, and testing them on the successive screen sizes to determine which contain true undersize.

In classifying with 12, 16, 22, 30, 40, and 80 mesh, for example, if "difficult" grains on 16 mesh contain little undersize on 30 mesh, and 30 and 80 mesh the same, the arrangement shown in Fig. 4 is sound.

If a series such as 10 and 30 and 30 and 80 mesh are too close, then the arrangement shown in Fig. 5 is tested. If the screen feed carries a high proportion of minus 18-mesh grains, the arrangement shown in Fig. 6 is best.

It may be found that "difficult" grains on 22 mesh may contain true undersize on 40 mesh, but this is fully compensated by using a double-length 40-mesh screen. The 80-mesh screen is tripple length, to accommodate the forward movement of "difficult" grains on 40 mesh,

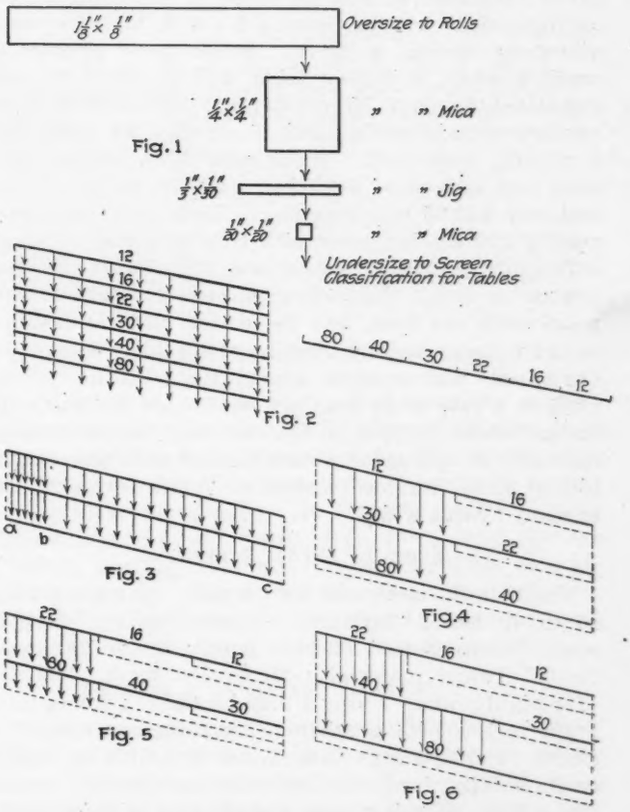



FIG. 1. MICA SCREENING DIAGRAM
Strong vibration used to toss mica, to get endwise engagement with slots

FIG. 2. COMPARISON OF SCREENING METHODS
In the superimposed method, the undersizes drop as shown by arrows. The oversizes report at ends of decks as finished products

FIG. 3. SCREENING DIAGRAM
a—b = non-difficult grains
b—c = difficult grains

FIG. 4. MULTIPLE SCREENING DIAGRAM
Undersizes on 12 and 30 drop to screens below. Undersizes on 16, 22, 40 and 80 are finished products

FIG. 5. MULTIPLE SCREENING DIAGRAM
Undersizes from 22 drop to 80. All other undersizes are finished products

FIG. 6. MULTIPLE SCREENING DIAGRAM
Preferable arrangement when screen feed carries high proportion of 18-mesh grains

and to give opportunity for excess quantity of minus 80-mesh grains.

In practice, the third method is usually employed, excepting in the few cases where certain grains blind the screen cloth excessively (as with zinc dusts and aloxite), in which a single and accessible deck is used. High-frequency vibration has, however, eliminated blinding to a great extent.

Screen classification before tabling is considered by many metallurgists as being highly desirable in theory, but seldom acceptable in practice. Failure in practice is due chiefly to the mill man's instinctive belief that

screening is a simple operation which deserves minor attention, with the result that accurate or efficient screening is seldom or never attained in practical ore-dressing work.

Tests for screening before tabling to determine such factors as increased efficiency, cost of equipment, and mechanical replacement can be readily and inexpensively made. At the Custer Peak Copper Co.'s mine, at Deadwood, S. D., a complete testing plant was built in five days and at a cost of less than $700. A platform, 30 x 30 ft., innocent of roof or sides, a small automobile, an improvised friction drive, a 3 x 4 ft. high-frequency vibratory screen, a 10-in. "coffee pot" grinder, a small crusher, a Wilfley table, and a 4 x 6 ft. tank completed the plant. Mine water was used. The table and crusher were borrowed, and 15 screen-cloth sizes, each 3 x 4 ft., were used. These screens, in metal, would have cost upward of $200, but cotton cloths were used, and only $13.65 was expended. Such cloths are more readily and quickly procurable than is metal cloth, are sufficiently uniformly woven, and will outlast the most protracted test. Supporting screens of light-wire 6-mesh cloth are used, and the cotton cloth is fastened on with tacks and is readily removable. Damp ore (as mined) was screened through the 1/200-in. opening cloth at a rate of 1½ tons per hour. Let me guide the inexperienced shopper so that he may not become discouraged by calling on a merchandise salesman to give him so many "meshes" instead of "price per yard" and so many "yards wide."

### Types of Cloth Screening

For 8 to 30 mesh call for "scrim" (curtain cloth); 16 to 40 mesh, "tarlatan" (cheesecloth?); 30 to 50 mesh, "marquisette" (I pass here); 40 to 100 mesh, "voile" (waist material); 60 to 150 mesh, "batiste" (for nightgowns—I pray I may be right); for opening 1/200 to 1/450 in., gingham. The foregoing are cotton cloths. For openings from 1/400 to 1/700 in., taffeta or china silks, irregular, but often serviceable, weaves. Use a linen counting glass (procurable at merchandise stores) to count the meshes and compare width of thread with width of opening to compute the size of the opening. The accuracy of results and ease of manipulation by adopting this method are surprising. In general, the higher the price, the smaller and more even the weave in each class. This shopping guide should transform a terrifying ordeal into a recreation—perhaps a delightful one if the right salesperson is encountered, and particularly so if one has just interviewed a few of the gentry who sell serviceable sand pumps!

That the statement may be heeded that screen classification has lost in competition with hydraulic classification because screens actually will not classify closely when ordinary methods are adopted, a report of efficiency in screening abrasives is given. At the Carborundum Co.'s plant, aloxite which had been screened on regular machines through 32 mesh and on 24 mesh was tested with laboratory screening and found to contain 45% through 30 mesh, and 10% through 40 mesh. And this occurred at a plant where accurate screening is religion! The vibratory screen in use in the majority of modern ore-dressing mills screens so inaccurately in this plant that it will not serve even as a closed-circuit screen, but is acceptable to these masters of screening only as a rougher preceding a closed-circuit trommel.

Couple these facts and realize how inaccurate is screening practice in ore-dressing mills. May it not be that screen classification is unpopular not because so much less satisfactory from the mechanical point of view than hydraulic classification, but because it is less accurate?

### Principles of the Vibratory Screen

The vibratory screen must be adjustable as to inclination and vibration amplitude; and its screen surface should be easily replaceable. That decreasing amplitude may be obtained as the discharged end is approached, vibration must be true-wire vibration, so that the amplitude varies according to screen-cloth tension.

The all-important factor is adjustability of vibration amplitude. The report of inaccuracy at the Carborundum plant is well founded, but the difficulty is not inherent in the vibratory screen. Amplitude must be controlled so that undersize does not "jump" at any point on the screen. The type of screen referred to has no means of controlling the vibration amplitude—a principle that was discovered accidentally. A hand screen (30 mesh) bearing unscreened aloxite was held against a strongly vibrating upright hickory spring, with the result that "jumping" of the grains, from 1 in. to 3 in., occurred. This was continued until no more undersize passed—until screening was complete. The screen was then removed and shaken quietly. A cloud of undersize dropped. There is no explanation other than that "difficult" grains do not pass when "jumped." Additional tests proved this assumption.

### Vibratory Screen Classification

Herein lies the true explanation of why certain inclined vibrating screens will deliver a 40-mesh product from a 20-mesh screen. Screening is incomplete, and "difficult" grains are not passed; for it will be found that, whereas the oversize does contain 40-mesh grains, the undersize, unfortunately, includes 20-mesh grains! The belief that an inclined screen offers the horizontal projection of its opening, and not the actual opening, has been found true to the limited extent that an angle of 35° effects a decrease of less than 10% of the opening.

At the Carborundum plant the tests were made with a vibratory machine, which, luckily, could be controlled to any degree of vibration amplitude. The following tests show the importance of this control. "Contamination" refers to the percentage of oversize found to pass a 30-mesh screen with an opening of 0.0230 in. The vibratory screen was 2 ft. 6 in. long; the trommel was 8 ft. long.

TABLE I. TESTS MADE WITH TROMMEL AND VIBRATORY SCREEN WITH ALOXITE ON 24-MESH, OPENING 0.0287 INCH

| | | Contamination, Per Cent. |
|---|---|---|
| (1) | Trommel | 13 |
| (2) | Vibratory screen at 32° inclination | |
| | With heavy vibration | 34 |
| | With light vibration | 6 |
| (3) | At 20° inclination | |
| | With heavy vibration | 26 |
| | With light vibration | 3 |

Sand remained on the screen longer at 20° inclination and with a heavy vibration than at 32° inclination with a light vibration, thus demonstrating that increased efficiency is due to the grains "hugging" the screen, and not to the fact that a longer time was allowed with a comparatively greater number of chances to pass through.

The percentage of "contamination" is less in this instance than referred to in regard to screening "through 22 on 24 mesh." "Contamination" varies with the quantity of "difficult" grains in the feed. Material which passes 22 and rests on 24 has obviously a high percentage of "difficult" grains. Screening efficiency cannot be properly expressed in terms of percentage with differing feeds. Equally good work may give 10% "contamination" with one feed and 60% with another. It is for this reason that the mixing of different grades of sands for the purpose of making comparison runs must be done carefully and completely.

Many know that the stationary inclined screen is more accurate that the vibrated screen. This is explained by the fact that "jumping" occurs with the latter type. The vibratory screen must be controlled so that the advantages of freedom from blinding and increased range of vibration are secured, and at the same time the accuracy of the stationary screen is retained.

It must be understood that true oversize, but not undersize, may be "jumped." In screening fireclay through 80 mesh, the oversize will "jump" vigorously and traverse the screen in one-tenth the time required by the undersize, which "hugs" it. The screening action of the high-efficiency vibratory screen on fine materials such as damp quartz through 1/250-in. opening, zinc dust through 1/450-in. opening, and fireclay through 1/125-in. opening may be hundreds of times better than with a stationary inclined screen, but the capacity may be no greater on dry materials through three mesh and coarser. With coarse sands, the blinding action is reduced by the adoption of vibratory screens.

The accompanying table gives rough approximations of tonnage, conditions for screening, and other factors:

TABLE II. SCREENING FACTORS

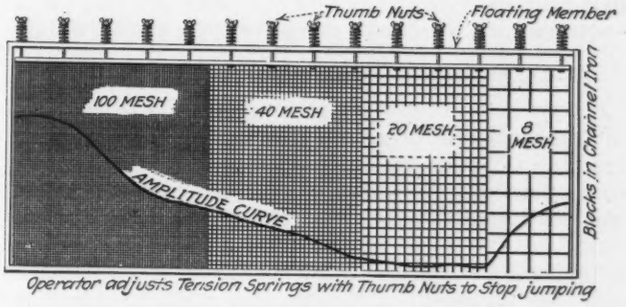
| | Dry Quartz — Mesh | | | | | Damp Quartz — Mesh | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 8 | 20 | 40 | 100 | 200 | 8 | 20 | 40 | 100 | 200 |
| Vibration amplitude (per cent. of normal maximum) | 20 | 5 | 10 | 30 | 40 | 30 | 15 | 40 | 80 | 100 |
| Inclination ratio (fall to advance) | 2:1 | 2:1 | 1.8:1 | 1.6:1 | 1.4:1 | 2:1 | 2:1 | 2:1 | 1.8:1 | 1.6:1 |
| Screen cloth length (inches) | 14 | 20 | 24 | 30 | 36 | 20 | 24 | 30 | 38 | 50 |
| Capacity, lb. undersize per hour per square foot screen area | 500 | 350 | 250 | 120 | 60 | 400 | 300 | 200 | 80 | 20? |

Control of vibration involves (1) control of screen-cloth tension, and (2) control of vibration amplitude through the control of the actuating mechanism.

## The "Jumping" of Particles

Where multiple sizes are produced in a single machine, each size will require a different vibration length. Again, where a single size is produced, the heavy bed at the feed end of the screen will require heavy vibration, so heavy, in fact, that the light bed nearing the discharge end will be "jumped," thus preventing the passage of "difficult" grains. Therefore, although the actuating motion may be under control, the vibration amplitude delivered will be the same at all screen areas, as each area requires a different amplitude. This apparently difficult problem is solved by the use of tension springs, which hold the screen cloth under the required tension, the vibration amplitude varying with the screen tension. Once adjusted, the adjustment stays. This type of control is applicable to true vibration only; the impact screen, hammer-action vibrated screens, and similar apparatus do not respond.

In the vibratory screen vibratory amplitude must not only be controllable, but easily and unchangeably controllable. Where high capacity and freedom from blinding are not important, a shaking screen, if properly designed to run smoothly, will take little head-room. On materials which are dry, but which tend to form into aggregations of small particles on screenings on 80 mesh and finer, the trommel has its place. However, a vibratory screen, with a simple brush arrangement, will doubtless be developed to meet this difficult problem. These aggregations are formed only when grains smaller




AMPLITUDE CURVE WITH DIFFERENT SCREENINGS

than 1/2000 in. are present. For example: aloxite, crushed 72 hours in a ball mill without discharge, is all but unscreenable on 1/200-in. opening, whereas the same material, with but 20% removed—as sands in suspension—will screen rapidly. In fact the high-frequency vibratory screen will screen even damp sand through 1/200-in. opening at a rate comparable with, say, 16-mesh screening. The forces responsible for formation of these aggregations of small particles have not been identified. Moisture plays but an unimportant part.

## Hydraulic vs. Screen Classification

With regard to screen vs. water classification, it would appear as if too much theory had beclouded the discussion. The obvious advantages of classifying large pieces of gangue with smaller concentrate grain have led speculative thought far from the true issue involved —the separation of minerals of little difference in specific gravity. For, where there is little difference in specific gravity, water classification will not result in the inclusion of larger gangue particles with the smaller concentrate grains. Water classification is a direct competitor with screening, and the choice will fall to the one which will effect the sizing the most accurately.

If grains differ widely in specific gravity, their separation on a modern table occurs regardless of classification. However, Richards gives as his latest report on tests of efficiency of hydraulic and screen sizing grains, differing widely in specific gravity, the following:

TABLE III. DISTRIBUTION OF VALUABLE MATERIAL IN CONCENTRATES, MIDDLINGS, AND TAILINGS

| Feed | Per Cent. of Valuable Material in Concentrates | Per Cent. of Valuable Material in Middlings | Per Cent. of Valuable Material in Tailings |
|---|---|---|---|
| Sized | 95 | 4.5 | 0.5 |
| Classified | 83 | 9.0 | 7.0 |
| Natural | 39 | 54.0 | 7.0 |

These data are taken from the *Journal* of May 18, 1918, p. 910, "Dry Sizing as a Means of Preparing Feed for Concentration," by George V. Bland.

Stripped of theory, the question is as to which system of classification is the best for the separation of minerals of little difference in specific gravity. These

fall into two classes: those of free minerals, as fluorspar and quartz; and those of included grain, as cassiterite (sp.gr. 7.0) and cassiterite attached to quartz (sp.gr., say, 3.9). The separation of true middling from tailing makes separate grinding and treatment of middling products possible, and in many cases permits the rejection of the tailing without regrinding.

A recent type of vibratory screen is capable of an output of 10 tons per hour per machine, which makes four products, 24, 30, 40, and 50 mesh. The finest screening—to prepare slime table feed as 1/200-in. undersize—is done at the rate of 4 tons per hour on a single machine with sands dampened to prevent dusting.

### Boulder County Tungsten Milling Practice

Screen sizing of ore before concentration is common, but screen sizing after concentration is not. At the Crescent, Colorado, mill of the Primos Exploration Co., a high-frequency vibratory screen was devised, and has been used continuously to screen canvas-table concentrates on 1/700-in. opening. The concentrate before screening assayed 18% $WO_3$; and, after screening, the undersize through 1/700 in. assayed 40%, the oversize (8% $WO_3$) being re-tabled without loss, fines not being present in that material. The fines could not be re-tabled, as the grains were too small to settle from suspension on the reciprocating table. This operation increased the net value of the concentrate from $175 to $325 per ton.

Boulder County tungsten practice has been reported as the highest development of the ore-dresser's art. Certainly no expense or complication as to equipment has been omitted. The high value of the crude ore and concentrate and, more particularly, the high penalty for imperfect concentrate, justified a great effort to achieve perfection.

I had the good fortune to become familiar with practice in all the important mills—at research work for the Primos Co. in its two mills, and, later, at screen-machine installations in three other important mills. Crushing methods are uniform in all the mills, but nothing else is. A notable innovation was jigging, to recover true middling in large sizes for separate treatment. This was treated with the coarse-sand table middling, and the procedure consisted of multiple-stage reduction, with intermediate tabling after close-screen sizing.

Slimes-recovery equipment was varied. The account of a system of screen analysis which was used to determine the comparative efficiency of the recovery of slime will serve to indicate the methods in use. With a given ore, the comparative efficiency of a slime-recovery method varies as the fineness of the grains recovered. A quick and wholly satisfactory method of determining the percentage of extremely small grains recovered is by means of the use of electroplated 200-mesh screen cloth (using a special combination of two metals) to obtain a screen of opening of 1/2000 in. and smaller. The procedure is to take a sample of definite weight of dry concentrate, which is screened with a sieve with 1/2000-in. openings. The screen should be "knocked" against a firm wooden member 500 times, with frequent brushing.

The comparative efficiency can be calculated from the weight of the undersize. For example: in one mill no concentrate was produced which would pass this aperture. No concentrating device was found which would report more than 20% through this opening, excepting canvas tables, which recovered 60% of the concentrate as grains smaller than the opening. Later, using thick pulp, on No. 3 Deister slimer and Deister Simplex slimer, grains as small as those from canvas tables were recovered in the form of a low-grade (20% $WO_3$) middling. This middling was made up of small ferberite and larger quartz, and responded to the same treatment as canvas concentrate—screening through 1/700-in. opening, sacking of undersize, and re-tabling of oversize.

With the modern slime table, fine concentrate grains are found associated with larger gangue grains. The largest concentrate grains ride the highest on the table. If this were true in the case of the riffled coarse-sand table (and it is not), how absurd would be the theory that large grains should be classified with small concentrate grains! If screen classification of sands be used for table preparation, special riffling and cross-wash conditions should be used to approach the action on slime tables.

Screen analyses on 1/2000-in. aperture were used to determine optimum pulp dilution as shown in Table IV.

TABLE IV. DATA OF OPERATION OF NO. 3 DEISTER SLIME TABLE WITH MINUS 200-MESH FEED

| Pulp Dilution ($H_2O$ to Sand by Weight) | Per Cent. of Concentrate Passing 1/2000" Opening | Grade Concentrate Per Cent. $WO_3$ | Feed Rate (Lb. per Hour) |
|---|---|---|---|
| 2.5:1 | 40.2 | 61 | 200 |
| 3:1 | 34.0 | 59 | 325 |
| 4:1 | 21.0 | 62 | 425 |
| 5:1 | 18.0 | 58 | 600 |
| 6:1 | 6.4 | 63 | 800 |
| 8:1 | 7.0 | 64 | 400 |
| 10:1 | 4.5 | 61 | 800 |
| 12:1 | 0.00 | 63 | 400 |
| 15:1 | 0.00 | 59 | 1000 |

The recovery of smaller grains in using a thick pulp has been explained by assuming that grains will stratify in a pulp which is thicker than may be required to pass them into suspension. Once on the deck, where agitation is far less than in the shear zone above, the smaller grains will progress into the concentrate (or middling). A future line of progress in gravity concentration may be suggested. Slime-table feed should be thicker than is obtainable with continuous thickeners. The manager of one of the New Jersey Zinc Company plants tells me that it is impossible to make a separation of slime unless it is fed dry to the table.

If dry preparation is found desirable, elephantine thickeners, which are utilized to get rid of water (which should never have been admitted to the flow), will not be used. True middlings will be separable from tailings, thus reducing the amount of coarse sands to be reground when fed dry. With the amount of water added under strict control, constant conditions of pulp are possible. With other conditions unvarying, a constant degree of pulp dilution will enable a clean cut to be made between minerals or middlings of little difference in specific gravity. As is well known, the difficulty of this separation lies chiefly in making this cut sufficiently close in maintaining a concentrate delivery at a given point.

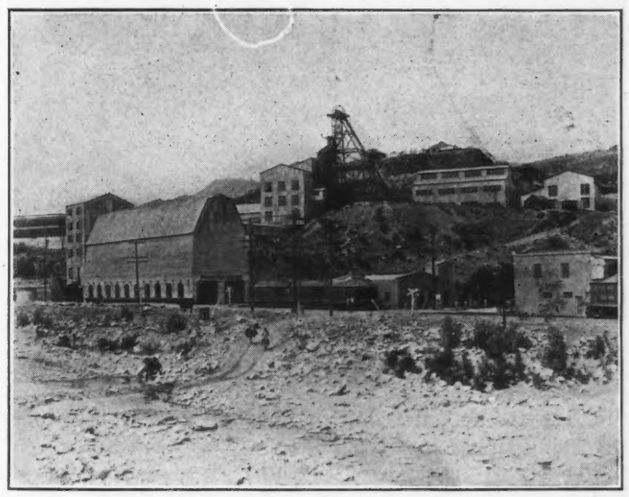
Thick pulp on the slime table decreases capacity. A compensating factor is that only one-quarter of the deck is used, making the use of a light, compact deck possible, and multiple superimposed decks practicable. A major objection to dry preparation is that no efficient dry grinder is available. Again, fine screens are not durable. However, electroplating of fine-mesh screens serves to increase wire size and surface resistance to abrasion. Such screens are brittle and are not practicable for use on most types of screen machines.

# The Arizona Hercules Copper Company's Plant

THE Arizona Hercules power plant and mill are at Hercules, Ariz., about half a mile from the Gila River and Kelvin, and 5½ miles from Ray, where the mine is situated. The water supply for Hercules townsite, power plant, and mill is obtained from shallow wells along the south banks of the Gila River. It is pumped to supply tanks through a 12-in. redwood pipe line by means of one 500 to 1000 gal. per min., two-speed, Scranton quintuplex pump.

The power plant was installed by the McIntosh & Seymour Corporation, and consists of three of that company's 1045-hp., 164-r.p.m., 6-cylinder, 4-cycle, Diesel engines, burning 14-gravity fuel oil in summer months and 24-gravity oil in winter. These engines are direct-connected to General Electric Co. 720-kw., 0.8 power factor, 2200-volt, 3-phase, 60-cycle generators, with direct-connected exciters. The first Diesel was started in April, 1918, the second in June, 1918, and the third in August, 1918. The fourth engine foundation is in place.

Power at 2200 volts is transmitted to the mill and pumping plant over a steel pole line. The power for the



GENERAL VIEW OF MINE PLANT

mine at Ray is stepped up in the power house to 44,000 volts through Wagner transformers, and transmitted over a steel pole line to the mine, where it is stepped down to the required distributing voltages. The load at the mine averages approximately 500 kw., with a hoisting peak of approximately 900 kw. The mill load is steady, amounting to approximately 460 kw. for each of the three mill sections installed.

### Lack of Power Has Hampered Output

The output of the mine and mill to date has been considerably hampered because of lack of power, caused by the experimentation necessary with this size of Diesel engine. One of the principal difficulties encountered has been in connection with the governor and camshaft gear, due to heating and cutting, caused by endeavoring to run the engines to their rated speed of 164 r.p.m., which speed it has not been practicable to maintain, the critical point averaging approximately 158 r.p.m. The air compressors are three stage, direct-connected to each engine; and some difficulty has been experienced by failure of the rings in the high-pressure cylinders, owing to valve troubles and improper lubrication.

Incorrect temperature of cooling water in the main cylinders has resulted in several scored pistons, that have resulted through uneven expansion of piston and liner. This trouble has been overcome to a great extent

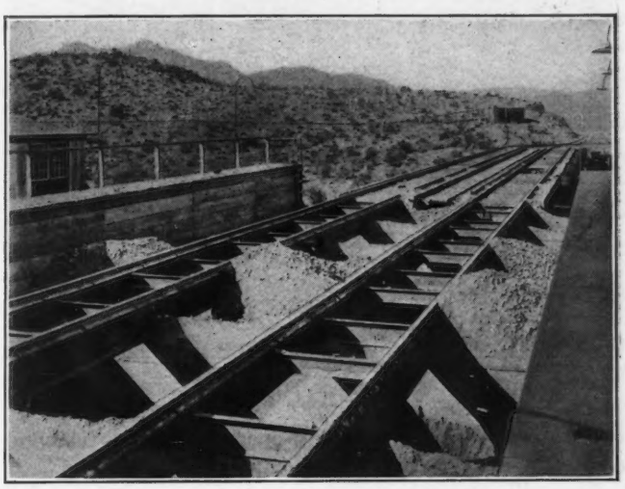


FIG. 1. TOP OF MILL ORE BIN

by increasing the cooling water temperature with the increase of the load. The original pistons have recently been replaced, by the manufacturer, with a new type having a heavier head, which was found necessary on account of the old heads cracking. The fuel consumption averages approximately 1 gal. of fuel oil per 13 kw.-hr. at full load.

Auxiliary equipment in the power plant consists of four centrifugal cooling-water pumps, two for the Diesel

FIG. 2. PORTION OF FLOTATION FLOOR, SHOWING CALLOW CELLS

engines and two for the cooling pond; and one 23-cu.ft., 1200-lb. air compressor, belted to a gasoline engine, for emergency purposes, in case the starting air is lost in the starting bottles. No water-softening apparatus is used, as the cooling water contains only a small amount of solids. The switchboard, which was installed by the

General Electric Co., consists of four exciter panels, four generator panels, and five distributing panels, equipped with Terrill regulators, and is in every way up to date.

With the installation of another generating unit, the present power shortage may be overcome. With only

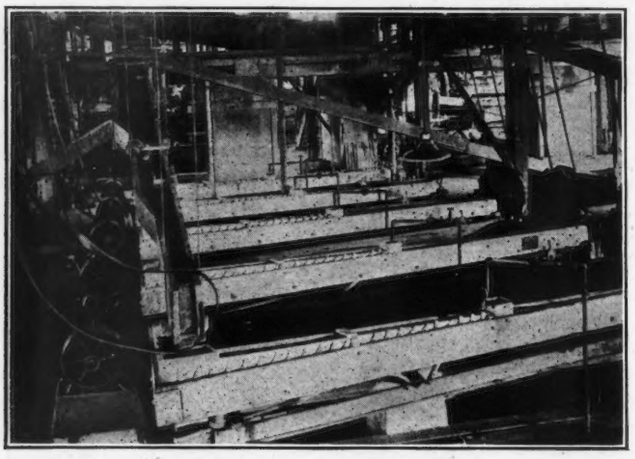


FIG. 3. PORTION OF THE TABLE FLOOR

two Diesels in operation, full operating power demand cannot be met. C. V. Ross is chief engineer.

The mill, consisting of three individual units of rated capacity of 400 tons each, was designed and built by Bradley, Bruff & Labarthe, engineers, of San Francisco, according to the flow sheet developed and drawn up by J. M. Callow, who was metallurgical engineer. The original flow sheet was that shown in Fig. 7.

The coarse-crushing plant and crude-ore sampling mill are at Ray, and consist of the following equipment: One Gates No. 8 gyratory crusher; one 54 x 20 in. Type AA Traylor roll; one rotary feeder, with Reeves speed changer, all of which are operated with a 150-hp. electric motor. The ore is taken from the mine ore pocket

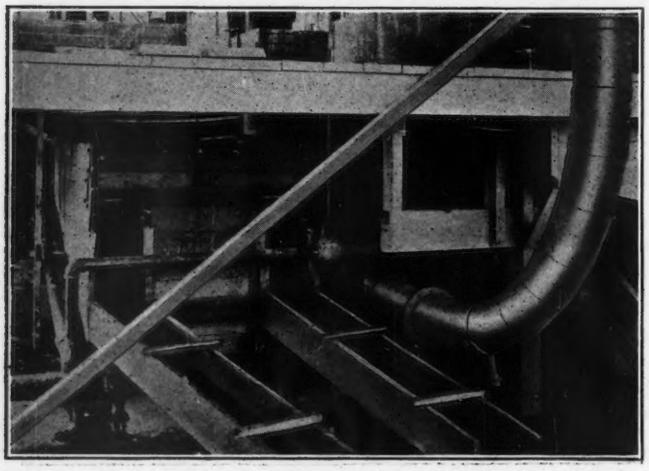


FIG. 4. BELOW FLOTATION CELL FLOOR, SHOWING LOWERED CLEANER CELLS. THESE CELLS ARE EQUIPPED WITH CONCRETE FILTER BOTTOMS

with a 5-ton skip, dumping into a 300-ton ore bin, and then fed to the crusher by an 8-ft. diameter rotary feeder, driven with a worm gear and controlled with a Reeves speed changer, Size 0, Style D. The ore leaving the feeder passes over grizzlies, which take the fine ore and leave the coarse to go through the crusher, which crushes to 3-in. mesh. The ore from the crusher passes over another set of grizzlies. The fines pass to the conveyor and the coarse passes to the rolls, the ore leaving the rolls direct to the conveyor being at an average of 1½-in. mesh.

The plant is able to handle 1200 tons in eight hours. A 30-in. belt conveyor, 300 ft. long, carries the ore from the rough-crushing plant to the sampling mill. The discharge from the conveyor is cut by an automatic, three-speed cutting device. Cuts can be made every 24, 32, or 48 seconds, making a full cut across the face of the discharge. The full discharge of the cut passes through a 10 x 7 in. Blake crusher; from there through a 16 x 10 in. Sturtevant roll, and then to the cutter, which cuts 4 to 1. The cutter rejects back to the ore bin, the remainder going to the finishing rolls, from which it again passes through the cutters, cutting 4 to 1, leaving the sample an average size of ¼ in. The full discharge from the conveyor empties onto the ore-bin conveyor, a 36-in. belt running the full length of the

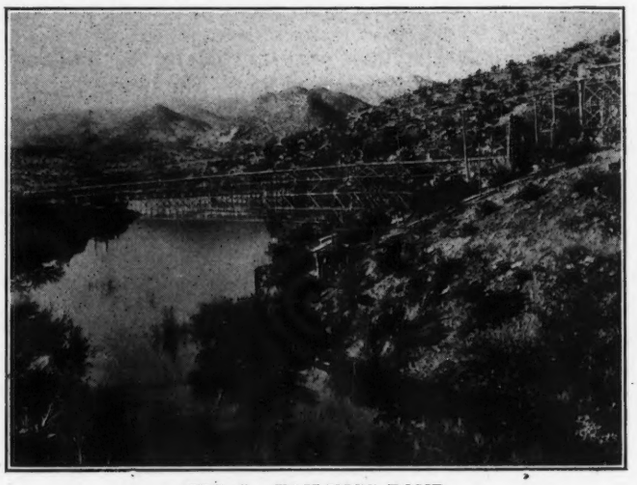


FIG. 5. TAILINGS POND

bin, 125 ft., and distributing through a self-propelling, reversing tipper into a 5000-ton capacity ore bin.

The ore is transported to the mill, a distance of 5½ miles, via the Ray & Gila Valley R.R., for 3¼ miles to Hercules Junction and thence over the tracks of the Arizona Hercules Copper Co. for 2¼ miles, in cars of 60-ton capacity, and dumped into the mill bin of 2000-ton capacity, for three mill sections.

During the first few months the mill was in operation, the character of ore treated was practically constant, the mineral being mainly in the form of chalcopyrite, with a small amount of chalcocite and a trace of native copper in a gangue composed principally of heavy green diabase. As the orebodies in the mine were opened up, the total copper content gradually increased, until at present the mill heads contain between 2.0 and 2.5% total copper, the greater proportion being in the chalcopyrite and chalcocite, with some native copper and copper oxide, the gangue consisting of granite porphyry, diabase schist, and talc.

The first section of the mill was placed in operation on Aug. 12, 1918; the second section soon thereafter, and the third section about the middle of September, 1918. The original flow sheet was as follows: For each section the ore was drawn from the mill bin by means of six roll-type feeders and conveyed over a Merrick automatic conveyor scale to one 8 x 6 ft. Marcy ball

mill, which is operated in closed circuit with one 6 x 22 ft. duplex Dorr classifier and is crushed approximately 90% through 48 mesh. The head sample was cut there with an Anaconda-type sampler, cutting every two minutes. This product was elevated by means of a 16-in. bucket elevator to eight 2 x 8 ft. standard Callow flotation cells operated in parallel. The tailings from these sells flowed by gravity to one 4 ft. 6 in. x 14 ft. 8 in. standard duplex Dorr classifier. The slime overflow from this classifier was returned by means of a 4-in. Krogh sand pump to four standard Callow cells in parallel. The tailings from these secondary cells went to a 10 x 40 ft. Dorr thickener, where clear overflow water was recovered and returned to the mill-water supply tank. The tailing discharge from this tank was sampled with an Anaconda-type sampler, cutting every two minutes.

The concentrates from all 12 Callow cells were elevated with two 10-in. bucket elevators to two standard cleaner cells, making a finished flotation concentrate. The cleaner tailings were returned to the main-feed elevator. The sand product from the 4 ft. 6 in. x 14 ft. uct was conveyed direct to railroad cars by means of three 16-in. belt conveyors.

To improve the operating efficiency of the plant, the flow sheet is being changed to conform to Fig. 6, as follows: The Anaconda-type sampler at the discharge of the primary Dorr classifiers was abandoned and the original product of all three sections was combined and redistributed to the main-feed elevators in order to make the operation more flexible. The size of the main-feed elevators was increased to 20-in. belts, equipped with 18-in. "AA" buckets. The eight primary Callow cells are being changed so that the initial feed will flow to four cells in parellel, the tailings from these passing direct to a second set of four cells in parallel. The tailings from the second set of parallel cells flow, as formerly, to the secondary Dorr classifier, the slimes from this classifier being pumped to four Callow cells, making the final tailings, 90% of which will pass a standard 80-mesh screen.

The rougher concentrates from all twelve flotation cells flow by gravity to two Callow cleaning cells on each

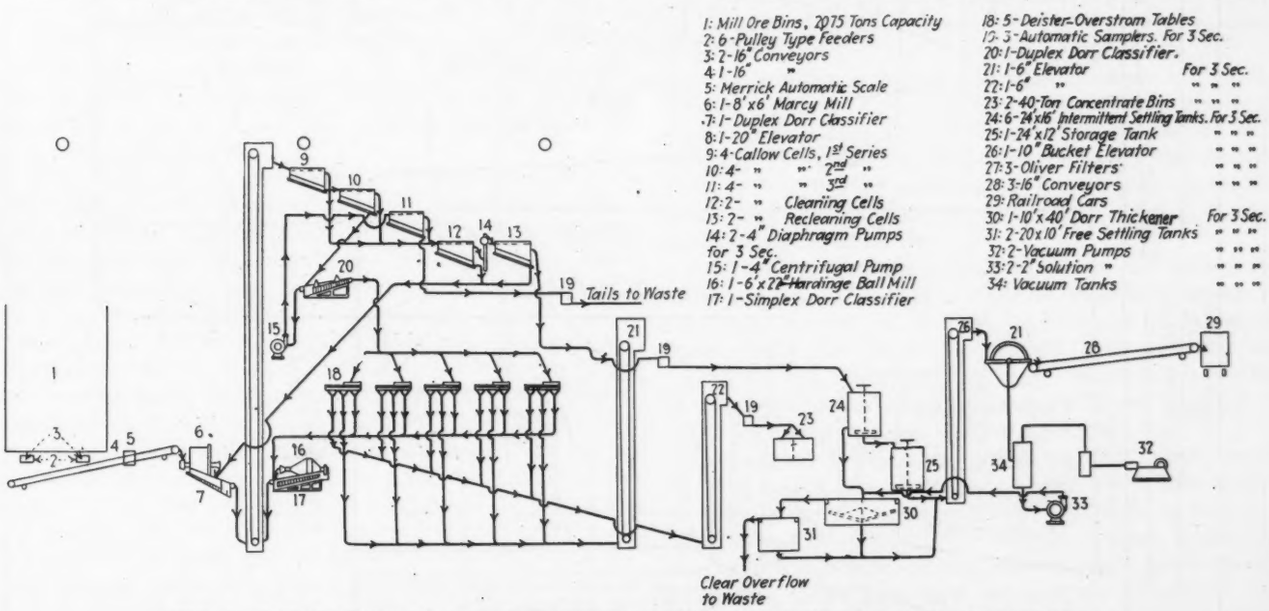

1: Mill Ore Bins, 2075 Tons Capacity
2: 6-Pulley Type Feeders
3: 2-16" Conveyors
4: 1-16" "
5: Merrick Automatic Scale
6: 1-8' x 6' Marcy Mill
7: 1- Duplex Dorr Classifier
8: 1-20" Elevator
9: 4-Callow Cells, 1st Series
10: 4- " " 2nd "
11: 4- " " 3rd "
12: 2- " Cleaning Cells
13: 2- " Recleaning Cells
14: 2-4" Diaphragm Pumps for 3 Sec.
15: 1-4" Centrifugal Pump
16: 1-6' x 22" Hardinge Ball Mill
17: 1-Simplex Dorr Classifier
18: 5-Deister-Overstrom Tables
19: 3-Automatic Samplers. For 3 Sec.
20: 1-Duplex Dorr Classifier.
21: 1-6" Elevator For 3 Sec.
22: 1-6" " " " "
23: 2-40-Ton Concentrate Bins " " "
24: 6-24'x16' Intermittent Settling Tanks. For 3 Sec.
25: 1-24'x12' Storage Tank " " "
26: 1-10" Bucket Elevator " " "
27: 3-Oliver Filters " " "
28: 3-16" Conveyors " " "
29: Railroad Cars
30: 1-10'x40' Dorr Thickener For 3 Sec.
31: 2-20x10' Free Settling Tanks " " "
32: 2-Vacuum Pumps " " "
33: 2-2" Solution " " "
34: Vacuum Tanks " " "
Tails to Waste
Clear Overflow to Waste

FIG. 6. FLOW SHEET OF ONE SECTION OF ARIZONA HERCULES COPPER CO.'S MILL

8 in. Duplex classifier was distributed to four primary Deister-Overstrom sand tables, from which a rougher concentrate was made and elevated by means of a 6-in. bucket elevator to one Diester-Overstrom finishing table, producing a finished copper concentrate and a middling tailing, which flowed to a simplex Dorr classifier, operated in closed circuit with a 6 ft. x 22 in. Hardinge ball mill. The reground overflow product was returned to the main feed elevator. The tailings from the primary tables joined the flotation tailings ahead of the 10 x 40 ft. Dorr thickener.

The concentrates from the finishing table were elevated by means of two 6-in. bucket elevators, accommodating three sections, and were combined with the flotation concentrates. The combined concentrates passed through an Anaconda-type sampler, cutting every two minutes, to size 24 x 16 ft. intermittent-type settling tanks, accommodating three units. The thickened product from these tanks flowed to one 24 x 12-ft. storage tank equipped with rabbles, and was elevated from this tank by means of a 10-in. bucket elevator to three 12 x 8 ft. standard Oliver vacuum filters. The filtered product was conveyed direct to railroad cars by means of three 16-in. belt conveyors.

To improve the operating efficiency of the plant, the flow sheet is being changed to conform to Fig. 6, as follows: The Anaconda-type sampler at the discharge of the primary Dorr classifiers was abandoned and the original product of all three sections was combined and redistributed to the main-feed elevators in order to make the operation more flexible. The size of the main-feed elevators was increased to 20-in. belts, equipped with 18-in. "AA" buckets. The eight primary Callow cells are being changed so that the initial feed will flow to four cells in parellel, the tailings from these passing direct to a second set of four cells in parallel. The tailings from the second set of parallel cells flow, as formerly, to the secondary Dorr classifier, the slimes from this classifier being pumped to four Callow cells, making the final tailings, 90% of which will pass a standard 80-mesh screen.

The rougher concentrates from all twelve flotation cells flow by gravity to two Callow cleaning cells on each section. The concentrates from these cells are pumped by means of tandem 4-in. diaphragm pumps to two 2 x 8 ft. pneumatic recleaning cells. The tailings product from all cleaning cells returns to the discharge from the Marcy mill, where it is used to control the density of the pulp in the primary Dorr classifiers, and replaces the fresh water used for this purpose.

The sand product from the secondary Dorr classifiers is distributed equally to the former four roughing tables and to one finishing table, making a finished and mixed native- and sulphide-copper concentrate, as well as a sulphide-copper concentrate. The total sand tailing is returned to the simplex Dorr classifier, which is operated in closed circuit with a 6-ft. x 22 in. Hardinge mill. The classifier overflow, of reground material, is returned to the main-feed elevators. With this flow sheet, there will be no tailings rejected other than those from the flotation machines.

The sulphide-table concentrates are combined with the finished flotation concentrates and treated as formerly. The mixed native- and sulphide-copper concentrates will be elevated to an Anaconda-type sampler, and

# Selection of the Power Plant for the Mill

By GEORGE J. YOUNG

*Power is required in modern milling practice and constitutes an important item in the operating costs. Efficient selection of the power plant demands a careful comparison of first cost of plant as well as of operating costs. Many appliances of excellent design and proved operating efficiency from which to select are available. A knowledge of what the machinery market offers and thorough acquaintance of the operating conditions are necessary for a wise selection of the type of plant and the individual units of which it is to be composed.*

IF A CONCENTRATING plant is not within convenient distance of a central power plant with electrical distribution, the selection of a suitable power agent and a plant for the generation of power and its distribution through the mill is the next most important problem after determination of the milling method and the design of the mill plan. Indeed, the form in which the power is to be applied will influence the mill plan to a considerable degree.

The most satisfactory form of power for use in a mill, as far as the distribution of the separate machines is concerned, is electricity. Electrical motors can be placed wherever convenient, and by the use of idler pulleys short-belt runs are practicable. Long shafts and heavy main-driving shafts can be avoided; and where there are a number of machines, such as concentrating tables, they can be driven as a group from a comparatively light shaft and by the use of light belting. Such shafts are so light and convenient that they can be placed in positions above the tables.

Motors can also be placed in positions that can be supported by the roof members of the mill, as the types of motors suitable for the operation of individual machinery or of small groups are relatively light and do not require excessively heavy supports. On account of convenience and adaptability of the driving machinery, electricity is therefore to be preferred to any other form of power agent in the mill. It is rare to find conditions that will require the use of a single driving unit and power distribution throughout the mill by shafting and belts.

## Principles Underlying Power-Plant Selection

It is the purpose of this article to point out some of the features of the power plant and the principles underlying the selection of the parts that compose its make-up. At the outset it will be assumed that the mill is to be electrically driven by induction motors, and that the problem concerns itself with delivery to the switchboard of the mill of the necessary amount of power in the form of a three-phase current of 220- or 440-volt potential.

The power agents that are to be considered are water, coal, wood, gas, gasoline, distillate, and crude oil. The availability of water power, either close by or limited to distances of considerable magnitude, as, for example, 20 to 30 miles, will determine largely whether this agent may wisely be considered. The cost of the power plant, together with its appurtenances, as well as of the power line and transformers required, is one consideration. Another no less important is the probable length of the operating life of the mill. If the available ore supply is such as to insure a reasonably expected length of operation of only two years or less, it is evident that the first cost of the power plant and its operating expenses over this short period will have to be apportioned over the tonnage treated during the two years of life, and will constitute a proportionally large charge. An operating life of five or ten years, on the other hand, will entail a much less unit charge for power. These are elementary considerations, but they are just as important in the planning of a small mill as in the installation of a large plant.

## Requirements for Water-Power Plants

A water-power plant requires a dam, headgates, ditch, flume, penstock, turbine, generator, regulating apparatus, switchboard and building. Conditions may be such as to make it possible to utilize simple and cheap structures, or the power development may entail a large expenditure. Here again the operating life enters as a determining factor. If it is relatively long, substantial construction may be permissible; but if it is short, the least expenditure consistent with fairly reliable operating conditions will rule.

Another important consideration is continuity of water supply. If water storage is necessary to insure continuous operation, it must be provided in those instances in which the normal stream flow is insufficient during the dry months of the year. Water storage may be cheaply provided under some conditions, whereas in others it may entail prohibitive expense.

The use of power agents such as coal, wood, crude oil, or special kinds of fuel—sage brush or other native material—depends upon availability. Facts as to quantity, cost, and reliability of supply require investigation before selection of any one of these fuels should be made. Conditions may be such as to restrict the selection to only one fuel; and this will determine, often decisively, the main details of the power installation. For example, if coal delivered at the nearest railroad point at a cost of $10 per ton be the only fuel that it is practicable to obtain, this fuel and a form of power plant that will permit of its use will necessarily be selected. If the power plant be situated twenty miles from the railroad-delivery point, a road and haulage facilities must be provided for the movement of an equivalent of about six tons of coal per day for every 100 hp. required (assuming a coal consumption of 5 lb. per hp.hr.).

## Coal-Handling Facilities

At the railroad point of delivery, unloading facilities for handling at least a carload of coal at a time must be provided, as well as facilities for loading haulage wagons or motor trucks. At the power plant, facilities for cheaply discharging the coal are also necessary. The labor involved will depend on the care taken in designing both unloading and handling details. It is evident that for a small power installation the cost of this equipment must be kept down, and the handling charges due to labor will be large.

will flow to two 40-ton free-settling concrete bins. The 10 x 40 ft. Dorr thickener formerly used for reclaiming water from the tailings will be used for final settling of the decanted water from the intermittent-type concentrate-settling tanks. A pump has been installed for reclaiming clear water from the tailings pond, for general milling purposes. The tailings are flumed from the mill to the tailings dam at sufficient elevation to provide storage for at least two years without further expense. The tailings dam is maintained by means of a "V" distributing launder at the face of the dam.

In order to improve the recovery of the native copper, an experimental concrete jig has been installed in one section, operating in the Marcy mill circuit, treating the return feed to the mill, and encouraging recoveries are being obtained. A research laboratory has been installed at the plant to conduct flotation experimental work in an endeavor to recover the metallic copper, together with the sulphides. The presence of metallic copper is an unusual feature of such ores. J. T. Shimmin, formerly mill superintendent for the Butte & Superior Co., is mill superintendent.

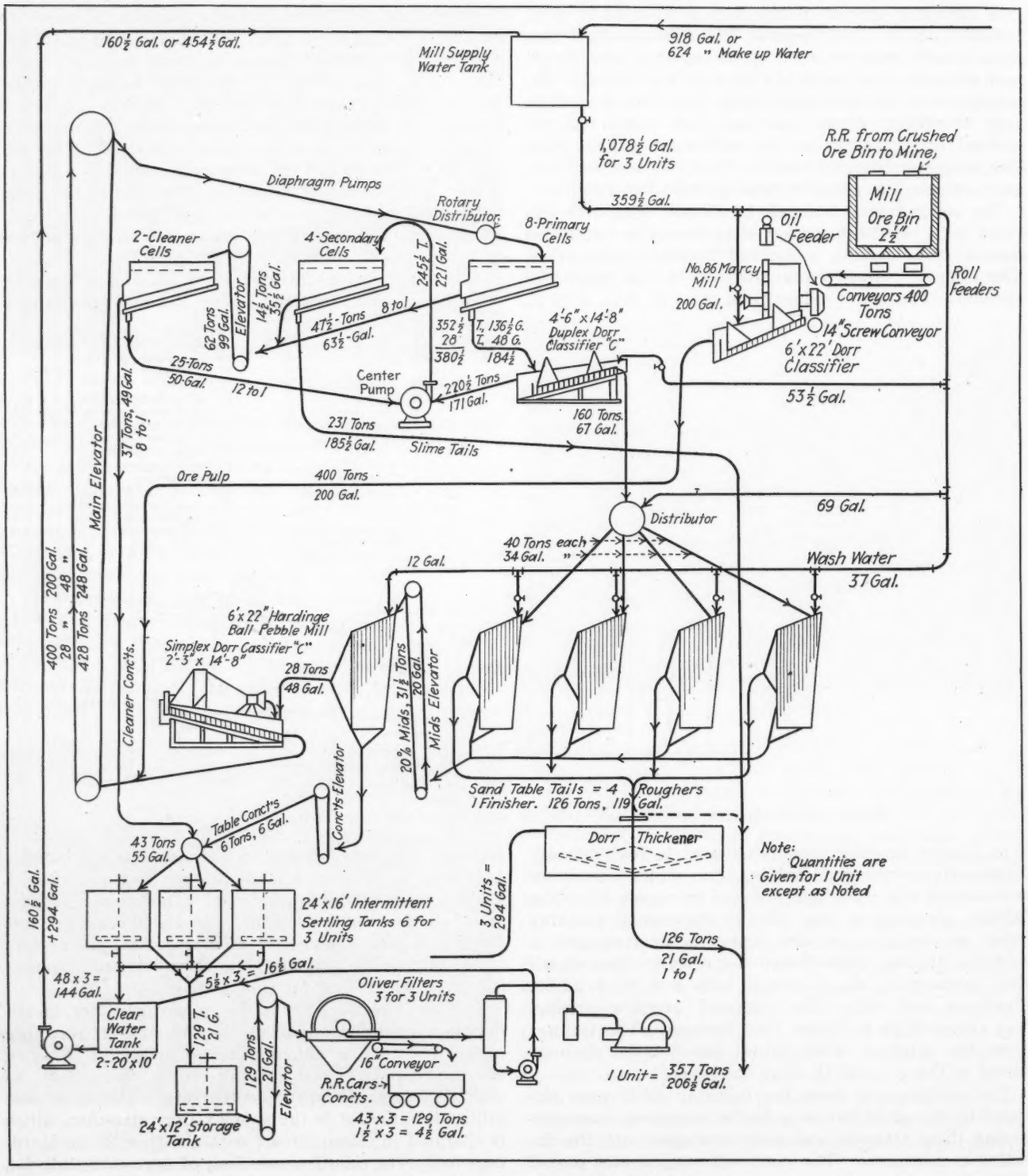

160½ Gal. or 454½ Gal.
Mill Supply Water Tank
918 Gal. or 624 " Make up Water
1,078½ Gal. for 3 Units
R.R. from Crushed Ore Bin to Mine
359½ Gal.
Mill Ore Bin 2½"
Diaphragm Pumps
Rotary Distributor
8-Primary Cells
Oil Feeder
2-Cleaner Cells
4-Secondary Cells
245½ T. 221 Gal.
No. 86 Marcy Mill
Roll Feeders
200 Gal.
Conveyors 400 Tons
14" Screw Conveyor
62 Tons 99 Gal.
Elevator
14½ Tons 35½ Gal.
47½ Tons 63½ Gal.
8 to 1
352½ 28 380½
T. 136½ G. T. 48 G. 184½
4'-6" x 14'-8" Duplex Dorr Classifier "C"
6'x22' Dorr Classifier
25 Tons 50 Gal.
12 to 1
Center Pump
220½ Tons 171 Gal.
53½ Gal.
231 Tons 185½ Gal.
Slime Tails
160 Tons. 67 Gal.
37 Tons, 49 Gal. 8 to 1
Main Elevator
Ore Pulp
400 Tons 200 Gal.
69 Gal.
Distributor
40 Tons each 34 Gal. "
Wash Water 37 Gal.
12 Gal.
6'x22" Hardinge Ball Pebble Mill
Simplex Dorr Classifier "C" 2'-3" x 14'-8"
28 Tons 48 Gal.
20% Mids, 31½ Tons 20 Gal.
Mids Elevator
Cleaner Conc'ts.
400 Tons 200 Gal.
28 " 48 "
428 Tons 248 Gal.
Sand Table Tails = 4 Roughers 1 Finisher. 126 Tons, 119 Gal.
Conc'ts Elevator
Table Conc'ts 6 Tons, 6 Gal.
43 Tons 55 Gal.
Dorr Thickener
Note: Quantities are Given for 1 Unit except as Noted
3 Units = 294 Gal.
160½ Gal. + 294 Gal.
24'x16' Intermittent Settling Tanks 6 for 3 Units
126 Tons 21 Gal. 1 to 1
48 x 3 = 144 Gal.
5½ x 3 = 16½ Gal.
Oliver Filters 3 for 3 Units
Clear Water Tank 2-20'x10'
129 T. 21 G.
129 Tons 21 Gal.
Elevator
16" Conveyor
R.R. Cars Conc'ts.
1 Unit = 357 Tons 206½ Gal.
43 x 3 = 129 Tons
1½ x 3 = 4½ Gal.
24'x12' Storage Tank

FIG. 7. ORIGINAL FLOW SHEET OF MILL

If fuel oil is to be used, tank storage must be provided both at the unloading point and at the power plant. At the unloading point the tank must be of sufficient size (10,000 gal.) to hold at least a tank car of oil (8000 gal.). At the mill the same or double the storage is preferable. For transportation, a tank wagon or truck is indispensable. For transferring from car to tank, a pump must also be provided. This will preferably be steam operated, as steam may be necessary to heat the oil in the car during the cold winter months. A steam boiler, pump, and building will be found essential, although sometimes a site that permits of gravity handling from the tank car to storage and from storage to tank truck may be available.

The problem of fuel transport is often such that it is preferable to place the power plant at the most convenient railroad point, and transmit power by high-tension current over the intervening distance, rather than to move the fuel to a power plant at the mill. Here again the engineer must work out comparative costs. One important objection to the last-described plan is the splitting of the plant into two widely separated units, entailing great difficulties in overseeing and in control.

### Use of Wood for Fuel

Wood as a fuel, where it is brought in by the railroad at a contiguous point, must be removed from the cars and piled conveniently close to the unloading spur. It must then be loaded upon wagons and trucks and hauled. A much simpler plant is required than if coal is to be used, although the handling of the wood involves high expense for labor. If wood is cut in the vicinity of the milling plant, a separate organization for logging and cutting must be maintained for a part of the year, or until the annual wood supply has been cut and hauled. The gathering of wood from a wide area, as is sometimes necessary, is not without its peculiar difficulties, and may require the construction of roads and skid paths.

Distillate, gasoline, or crude oil, when these are used for power purposes in some form of oil engine, are transported in drums. They are unloaded upon a platform at the rail point and transferred to wagons or trucks. From two to three drums of 100 gal. each are required per 100 hp. per 24 hours. The haulage of this amount involves little difficulty and comparatively small expense, even when the distances are considerable. Of all of the power agents excepting water, the oils or gasoline which are used in oil engines are of the least bulk and weight and of least cost, per unit of power developed, for their transportation to the mill. The labor or handling is obviously lighter than for the fuels which are used in a steam-power plant.

### Simplicity and Reliability Important Factors

Having decided upon the form of power agent, the next important point is the selection of the kind of power plant. The principles that determine the selection are relatively simple—simplicity and reliability. Continuity of power service requires that a plant should be as nearly fool-proof as possible. To meet this condition, machinery must be selected that can be handled by the average operating skill and knowledge available. If complicated and delicate machinery is to be installed, a commensurate degree of mechanical ability and knowledge must be provided, by the securing of operators who can meet these requirements.

Third is the cost of power generated. Closely related to this is the first cost. First cost will depend upon the kind of machinery and the degree of complexity. An elaborate steam-power plant, with all of the auxiliaries necessary to utilize the fuel in the most efficient manner, will cost several times as much as a simple steam engine and boiler. Here again enters the factor of the length of life of the plant. A relatively large first cost is permissible where the plant is to be operated for ten years, but for two years' operation a low first cost would be highly desirable.

### Accessibility Must Be Considered

The accessibility of the plant site and the cost of freight are other factors of no small importance. Obviously, the more elaborate the plant the greater the difficulty of transporting its component parts and the greater the cost per unit of power installed. In some localities, the transporting in of the simplest kind of plant may be all that is possible. In addition, the engineer must consider the question of erection difficulties. The erection of a complicated plant often requires the services of highly skilled mechanics, and such mechanics may have to be brought to the mill site at considerable expense. In addition, the kind of water available for steam boilers is an important consideration. This may be of sufficient importance to be a deciding factor.

In the foregoing I have laid down some general principles, and there remain to be considered some of the more particular details of steam and internal-combustion power plants. These will be divided into four groups—the steam plant, the distillate-engine plant, the gas-producer plant, and the Diesel-engine plant.

### The Steam Plant

There is a comparatively wide range in the selection of the essential parts of the steam plant. In the following grouping I have placed together a number of standard arrangements:

A—Boiler
Steam engine
Feed-water pump

B—Boiler
Steam engine
Feed pump
Feed-water heater

C—Boiler
Compound engine
Feed pump
Feed-water heater

D—Boiler
Compound engine
Condenser
Feed pump
Feed-water heater
Oil filter

E—Boiler
Stoker—automatic
Compound engine
Condenser
Feed pump
Feed-water heater
Oil filter
Superheater

F—Boiler
Turbine
Feed pump

G—Boiler
Turbine
Condenser
Feed-water heater
Oil filter
Feed pump

H—Boiler
Superheater
Turbine
Condenser
Feed-water heater
Feed-water pump
Oil filter

I—Boiler
Superheater
Stoker—automatic
Turbine
Condenser
Feed-water heater
Feed-water pump
Oil filter

The groups range from the simplest to the most complex. They also range from the least economical in fuel requirement to the most economical. Probably it can also be said that they range from the plant in the installation and operation of which the least amount of mechanical ability is demanded to that which requires the most. It will be noted that there are two main groups, A to E inclusive and F to I inclusive, the first group being characterized by the reciprocating steam engine as the prime mover and the second group by the steam turbine.

What has been said applies to either group within it-

self. As between the two groups, the second group represents the more modern and also the simpler mechanically, although perhaps a higher order of mechanical ability is required to keep the turbine in good operating condition than is demanded in the operation of the steam engine. Each has its individual peculiarities. Progressively in each group there is a decrease in cost per unit of power obtainable from the plants indicated, as well as an increase of weight per unit of power generated, and also an increase in cost per unit of power installed. The unit weight per power unit is less in the second main group.

An increase of economy in operation is invariably accompanied by a considerable increase in the first cost of the plant. It is also obvious that as the number of parts are increased there must also be an increase in the amount of care and attention demanded of the men who are to operate the plant.

To continue the generalization, it may be pointed out that where the fewest parts and the least weight are desirable, groups A and F meet the requirements, but they would necessitate the greatest amount of fuel for operation. If fuel were obtainable at low cost, the use of plants of this kind might be justifiable. Also, where first cost is the dominating essential, both plants would meet the requirement, with A as the least-cost plant. On the other hand, if economy of operation be the first essential, groups E and I would meet this requirement, with preference given to Group I. The intermediate groups in each main group would show progressively greater and greater economy. The limits of this paper do not permit going into the detail of the selection of the particular type of boiler or engine or other parts of the plant, but it is evident that correct judgment and a knowledge of the operating conditions are necessary before these can be selected from the great variety offered by the machinery market.

### The Distillate-Engine Plant

The unit of this plant is the single- or double-cylinder, horizontal type of oil or distillate engine. In weight per unit of power generated, this plant is comparable to Group A (steam plant). In complexity of arrangement and number of parts, there is much in favor of this plant as compared with the steam plant. In economy of fuel, there is also a materially greater saving over any one of the steam plants. Hence, where fuel is expensive and difficult to obtain, the distillate plant has the decided advantage of requiring the least weight of fuel in the form of a liquid, which is more easily handled than solid fuel. From an operating standpoint, the distillate engine presents rather more difficulty than the steam-engine plant, although with experienced men this is more apparent than real. The labor required in operating is measurably less than for any steam plant requiring solid fuel. In compactness of plant, less housing space, the distillate plant has the advantage. The first cost of the distillate plant is less than that of the more economical steam plants, and is probably about equal to the first cost of the steam plants in groups A and F.

### The Gas-Producer Plant

The essential features of the gas-producer plant are the gas producer, the scrubber or purifier, and the gas engine. All are simple, and the arrangement is somewhat more compact than that in the steam plant. The advantage of the plant is that suitable solid fuel, as, for example, clean anthracite coal or charcoal, can be used, and an economy of the same order of magnitude as that obtainable with the distillate engine obtained under ordinary operating conditions. With clean gas, little trouble is experienced with the gas engine. The labor of operation is less than for a steam plant of corresponding size. The operating skill required is not any greater than that required for a steam plant.

The weight per unit of power installed is somewhat more for the producer plant than for a steam-power plant of equivalent power. In portability the producer plant does not present much more difficulty than the steam plant. Probably the greatest difficulty experienced is in the obtaining of suitable fuel. Theoretically, many fuels can be gasified in the producer, but the problem is to clean the resulting gas without too elaborate scrubbing appliances. The competition of the crude-oil engine as well as the Diesel type has been an indirect factor in the lack of interest shown in the gas-producer plant, and it is likely that this form of power plant will be used only under conditions that particularly favor it.

### The Diesel-Engine Plant

The Diesel internal-combustion type of engine and its modification, the hot-bulb engine, are, from a weight standpoint, heavier per unit of power installed than the simple steam-engine plant and about equal to the more complicated steam plant. In economy of fuel per unit of power generated, these types have an advantage over all of the forms of power plant mentioned. C. G. Sprado says, in the May 20, 1919, issue of *Power*:

"Although the Diesel engine operates with an economy which is unequaled, its reputation has been damaged in some instances from its being used under unsuitable conditions, but more especially by unskillful handling. Over-enthusiastic advocates of the Diesel engine have injured its reputation by leading purchasers to believe that the machine was 'fool-proof,' and required no operating skill; but, as a matter of fact, in return for its high economy the Diesel engine demands a certain amount of attention (such as in connection with grinding valves) at the right time; and there are instances where the machines in duplicate installations have either been highly successful or failures, dependent entirely on the degree of skill of the operating crew.

"The Diesel engine is practically a 'maximum-rated' machine, for its power is limited by the volume of air compressed in the main cylinders, the amount of oxygen present determining the quantity of oil that can be given perfect combustion. It can readily be seen that on this account Diesel engines are limited to small overload capacity, for comparatively short periods, but they will operate with relatively high economy on lighter-than-maximum loads.

"In common with all moderate-speed internal-combustion engines, the Diesel has a relatively high first cost per brake horsepower; and to offset this there has been a tendency among builders to over-rate their engines both as to capacity and speed. Although this may do no harm on fluctuating loads, it is sure to give unsatisfactory operating results on continuous heavy loads such as are encountered in marine work, pumping and flour mills, owing to overheating, carbon from incomplete combustion, and other causes."

The fact that the Diesel-engine type of power plant has found extensive application in marine service is sufficient testimony of its reliability. In the mining industry the principal difficulty attending its use has been lack of skilled operators. Steam-engine operators have been comparatively numerous, but there has not been sufficient time to develop a relatively large number of operators who have sufficient experience to keep the Diesel in running condition. Manufacturers of this type of oil engine have had to train the men for operating service. This is a condition that is rapidly passing, and with it will come a more extensive use of this form of power plant in mining districts where fuel is expensive and where it has to be brought in from long distances.

The extensive development of petroleum districts in many parts of the world insures a supply of suitable fuel for the Diesel type of prime mover. The relative amounts of fuel oil required in the more economical steam plant as compared with the Diesel plant and its modifications are as 3 or 2.5 to 1. On a 500-hp. unit operating 20 hours per day and 350 days per year, or 3,500,000 hp.-hr., the approximate weights of fuel oil would be 3500 tons to 1050 tons, the lower figure being the crude-oil requirement of the Diesel.

### General Conclusions

The choice of the power plant from the standpoint of operating economy may be made from one of the following three types—the water-power plant, the steam-power plant of either group H or I, and the Diesel-engine plant or one of its modifications.

If water power is available, there is little question as to the wisdom of selecting this form of power plant. Similarly, where fuel cost is high, and fuel must be transported in, and fuel oil is reasonably available, the last-mentioned form of power plant will be selected. Where oil cannot be obtained, and wood or coal is available, the steam-power plant remains as the solution of the power problem. In any one case where a number of possibilities are present, the selection of the power plant rests primarily upon the determination of the comparative first costs and the comparative unit-power costs by the different systems.

## Flotation and Retorting of Sulphur

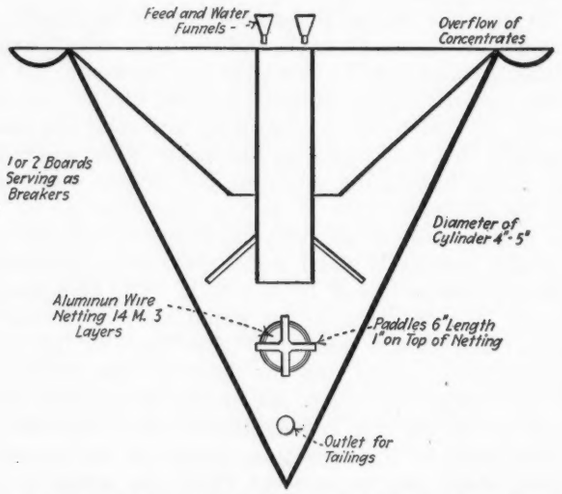
By P. F. Junehomme

The following notes and results, obtained by experimental flotation tests on samples of gypsum containing free sulphur, may be of interest, although prices have dropped, and the stimulus for the development of low-grade sulphur minerals no longer exists.

The gypsum rock in question contained free sulphur, varying in amount from 37 to 6%. The colors of the earthly substances and the hard rock were white, yellowish, brown to green, and even purple. The extraction of sulphur has been carried on in retorts, and the results have been sometimes successful, but often with considerable losses in the residue. A practical retort system has not yet been devised. The size of retorts necessary to bring the sulphur to the melting point, and the time of maintaining the heat at a sufficient temperature and under efficient pressure to exhaust the mineral of all the sulphur, have not yet been determined. Often the retorts have been built so large that radiation of heat is too great and the extraction of sulphur in low-grade ores is impossible. In high-grade ores considerable losses occur in the residue.

Flotation experiments on sulphur rocks have proved successful. A combination treatment involving flotation, and the retorting of the sulphur in the concentrates produced has been tried and has given excellent results. The tests were made on rocks and on fines containing up to 36% sulphur. A sketch of the spitzbox machine used to make the experiments is shown herewith.

The high-grade ore assayed 35%, and 20 lb. was taken for treatment. After 20 minutes' treatment in the machine, the concentrate, which overflowed into a canvas bag, was collected, squeezed dry, then dried in the sun. The sulphur contents assayed 76%. The tailing assayed 1.4% S, so the extraction was about 96%. The concentrate was re-treated in the machine and the per-


Feed and Water Funnels
Overflow of Concentrates
1 or 2 Boards Serving as Breakers
Diameter of Cylinder 4"-5"
Aluminum Wire Netting 14 M. 3 Layers
Paddles 6" Length 1" on Top of Netting
Outlet for Tailings

SULPHUR FLOTATION EXPERIMENTAL MACHINE

centage of gangue still further reduced. The usual rules as with treatment by flotation of ordinary copper and silver sulphide ores were observed. The ore was first crushed to about 20 mesh; then mixed with water in the ratio of one to one, and introduced into the receiving funnel through a hose or pipe, with a continuous stream of water from another ½-in. pipe. From 0.05 to 0.10% of gasoline was used in the first treatment in the machine, and half this amount for the subsequent treatment. Some foaming took place, due to the fine dust present.

An attempt was made to retort the sulphur, without success. It was found that it must be either briquetted with some binding material, and then broken up in pieces not larger than 1 to 1½ in., or charged with hard stone pebbles, of 1 to 1½ in., or hardwood blocks or cubes. The temperature of the steam should be at least 300 to 350° F. The perforated cage which holds the charge in the retort should be made of sheet aluminum, as the melting sulphur will soon destroy one made of sheet iron or steel.

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**Ferromanganese, Ferrosilicon and Ferrochrome** will be manufactured by the Tennessee Manganese Co., Knoxville, Tenn., by the electric-furnace method, according to plans now under consideration. The first 10-ton furnace will be situated at Cleveland. Manganese deposits in Tennessee are controlled by the company. Its highest-grade chromium ore is 50 per cent.

# Report on Economies in Mill Parts in South African Gold Mills*

During the year 1916, the tightening up of restrictions in England on the export of supplies for the mines made it imperative that concerted action should be taken regarding economies to be practiced at the South African mines, and, where possible, that substitutes for imported articles should be made locally. Previous to that year the large local stocks of necessary engineering supplies had not made the matter so urgent, but certain economies and useful ideas were being developed at individual mines, and it was evident that, if a free circulation of this information could be accomplished, the mines of the group would be greatly benefited. Many interesting and unique devices in connection with mine machinery were evolved by various engineers, and it was felt desirable to summarize the many economies which had been effected. The following is a list of the principal items:

*Stems*—Stems are made at many mines from old camshafts or by faggoting up three old stems, at a cost averaging about £3. Stems are also repaired by welding on any suitable scrap material. Many mines report that one or other of these ideas has long been practiced.

*Cams*—New Modderfontein—Worn cams are brought up to shape by welding on pieces of rail or drill steel, at a cost of about £2 10s. per cam. The Knight Central fullers up the cams and, when necessary, welds in a piece of drill steel. The cost is stated to be £1 per cam. Ferreira Deep, Ltd., draws out old worn cams from root to standard size. This was the practice prior to the war. Crown Mines, Ltd., have made up a few cams by quasi-arc; first results not good; could be improved.

*Heads*—Ferreira Deep, Ltd.—When badly worn in socket, are heated up, compressed, re-bored, and put again into use.

*Shoes*—Several methods are being tried for replacing broken shanks on shoes. New Modderfontein welds a worn-out shoe on to the broken one. This is economical if the weld holds, but definite information on this point is not yet available. A more usual method is to draw a new shank out of the shoe under hammer, which makes a satisfactory job, not, however, invariably successful, variation in quality of steel sometimes causing the shoe to split. It is stated that two hours are required to form a new shank like this, so the cost would be about 10s. Rose Deep bores out shoe and shrinks in a mild-steel shank at a cost of about £1. Another mine converts old tappets into shoes by welding on a shank.

*Dies*—It is now the general practice to make dies by cutting an old head in two and filling holes with shoe shanks. This costs about 15s. for two dies.

*Camshafts*—Witwatersrand Deep, Ltd., makes camshafts of five stems faggoted up together. Other mines weld up broken camshafts, with varying success.

*Blanton Gibs*—Crown Mines, Ltd., has found a gib with feather on key much superior to the gib with two pins. The holes for pins are frequently drilled too deep and become a source of weakness in camshafts. The keyway would appear to add 50% to life of camshafts. At Ferreira Deep, Ltd., all pin-holes in camshafts are drilled in fitting shop to gage ¼-in. deep, by using flat-faced drill with sleeve on to prevent possibility of drilling too deep. Considers cutting keyways and fitting key an unwarranted expense.

*Mortar-Box Liners*—At the Crown Mines, Ltd., mortar-box liners are made from old camshafts, at a cost 50% under imported ones. Similar liners are being made at some of the mines from old dies.

*Wood Guides*—In connection with the practice of reboring wood stem guides, the Knight Central, Ltd., finds it pays to buy extra-thick timber for the outside guides. In this mill the inside guide against the girt cannot be more than 4 in. thick, but the outer one can be 4½ in. This extra ½ in. gives a much longer life to half the guides. At the Ferreira Deep, Ltd., it is the practice to start guide with ¾-in. liner between halves, and as holes wear the liner is reduced until they come face to face; ¾ in. is then cut away from the face of each half of guide block and restarted with a ¾-in. liner. The same procedure is carried out until blocks are completely worn out. Any odd hole worn out of proportion is lined with rawhide liner. By this method an average life of seven years is attained. Other mines adopt similar methods for economies in guide blocks. At the Crown Mines, Ltd., economy is achieved by lining guides with discarded leather ("Hendry") belting. Leather lining is not a new idea, but tacking on strips is novel, having the advantage of enabling the shape of the box to be maintained. Still further improvement is effected by battery screening.

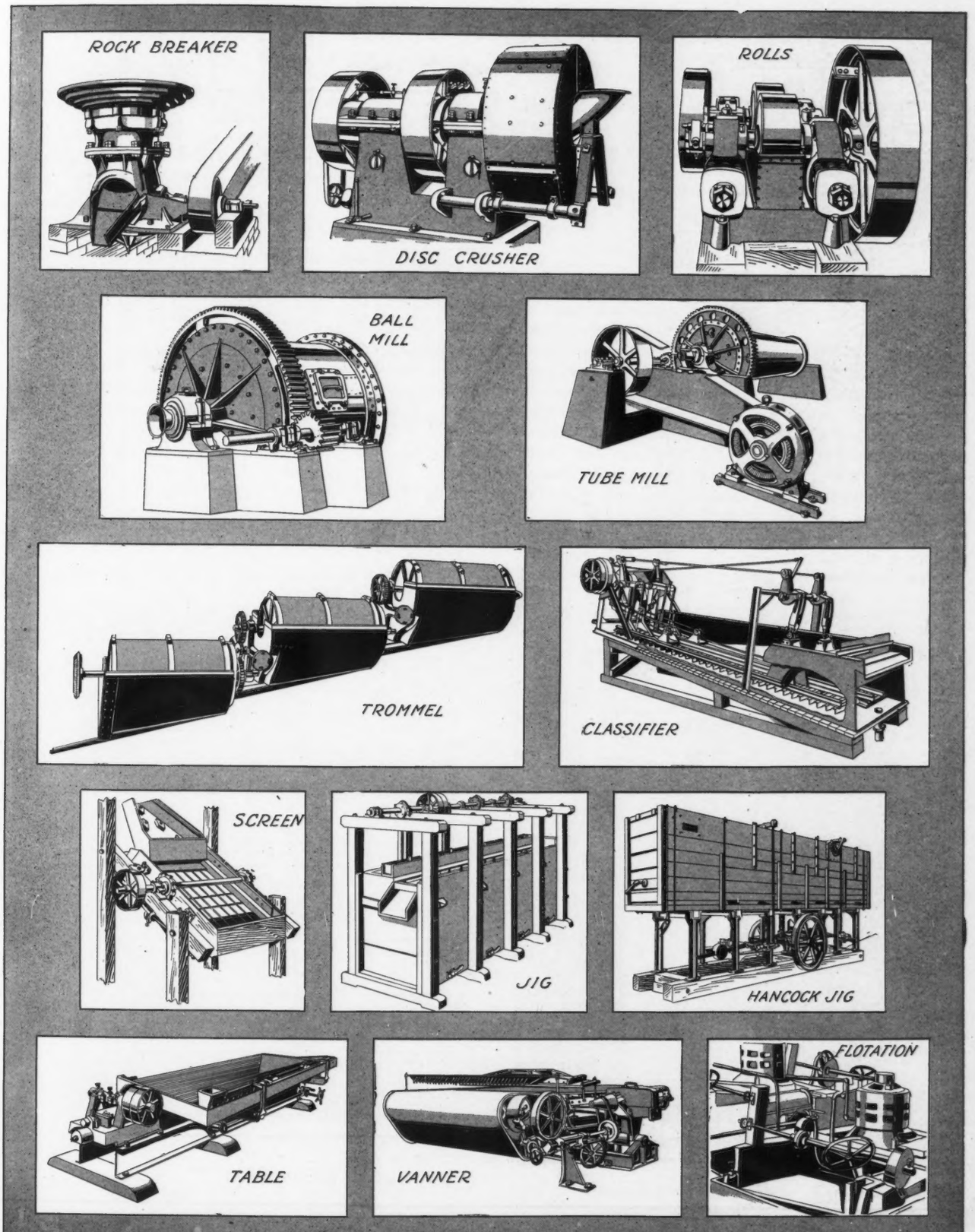
*Boilers*—An interesting boiler repair job, which saved the company an expenditure of £300 on the boiler tubes, was carried out at the New Heriot Gold Mining Co., Ltd. Through removal for cleaning, the tubes of an F. & C. boiler, 104 in number, had worn out at the ends. By cutting 2 in. off each end of these tubes and 4 in. off the boiler shell, all the tubes could be used again. The entire job cost £60. East Rand Proprietary Mines, Ltd., reported that the method was new to that mine. It is the practice to cut and weld tubes to suit the boiler, and the management considers this the better method. Welding tubes has been the practice at this mine since the war started. At the Crown Mines, Ltd., shortening of boilers has been in practice with Sterling boilers in order to make further use of tubes; it is also being done to facilitate transport.

*Crushers*—The Bantjes Consolidated Mines, Ltd., carried out an economical repair job on a 30 x 12 in. Hadfield crusher. The engineer made a pair of case-hardened toggles from camshaft at a cost for labor of £3 5s., which allows an ample margin for power costs and similar charges, compared with the imported price of £9 10s. From similar material a wedge block toggle seat for 30 by 12 in. Hadfield crusher has been made. The Ferreira Deep, Ltd., uses F. & C. of Hadfield's 10 by 20 in. and 12 by 30 in. crushers. All toggles when worn badly are re-formed at a cost of 8s. each. Broken toggle blocks are re-plated by mild-steel ones made at mine; also back wedges for fixed jaw faces. The East Rand Proprietary Mines, Ltd., have made wedge blocks and toggle seats from this material. Making crusher parts from old camshafts or suitable scrap has proved to be a valuable economy.

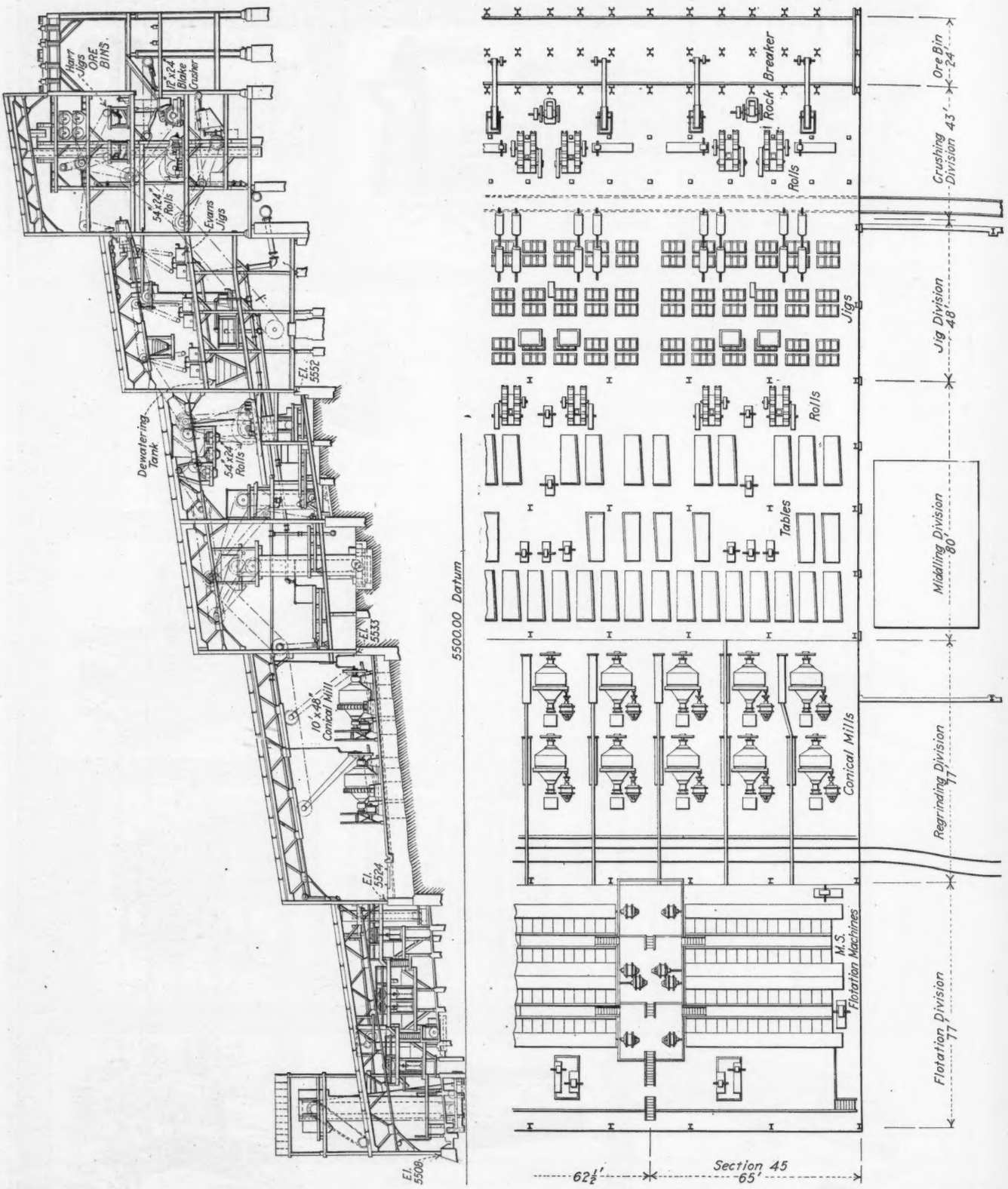
*Excerpt from an article in *Journ. Chem. Met. & Min. Soc. of S. A.*, Dec., 1918. p. 89.

**Claims Filed With the War-Minerals Commission** by Utah producers of such minerals show a total of $20,000 to have been asked by companies producing manganese, five in number; $2500 by one company producing pyrites; and $7000 by one company producing tungsten.

In Agricola's time milling was accomplished by crude appliances and human muscle, and the result was small tonnages, low recoveries, and indifferent work. Considerable ingenuity was displayed by the early "mill men" in inventing appliances




In modern time, all milling machinery is power-driven. There is an appliance for every step. Methods of separation have multiplied. Tonnages are large. Recoveries reach high percentages, and milling work is done under exact control




In sharp contrast to the Agricola picture is the arrangement of a modern milling plant. On this page is shown a plan of a section of the copper-concentrating mill of the Anaconda Copper Mining Co., at Anaconda, with a vertical section

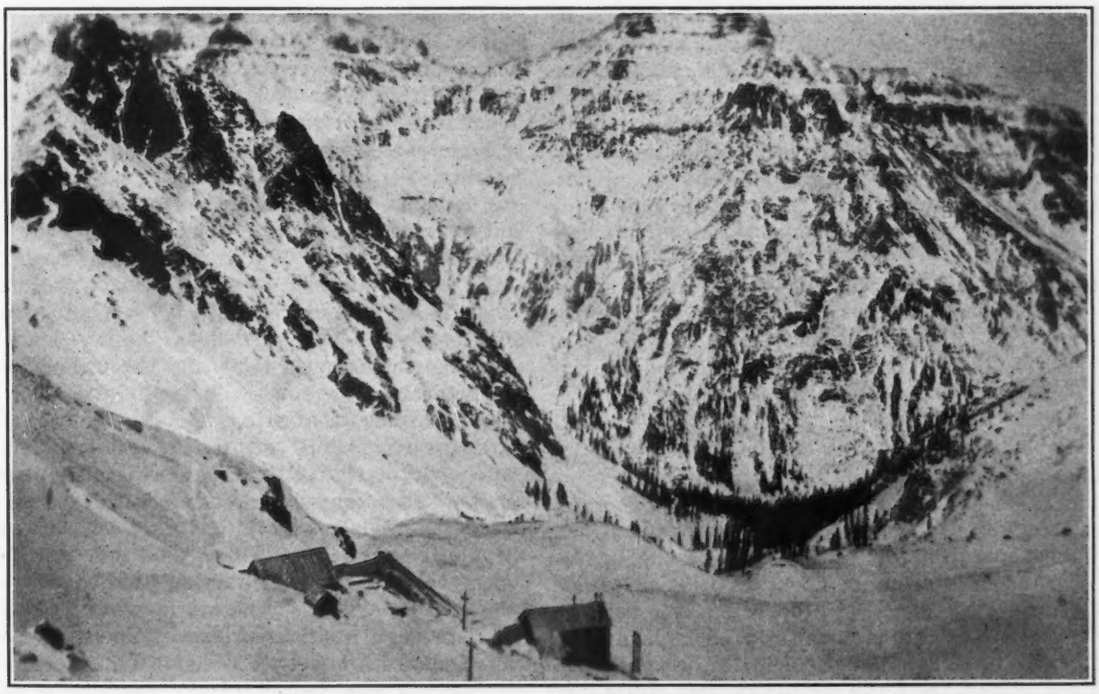
# Milling in the San Juan, Colorado

By CLIFFORD R. WILFLEY*

*The San Juan region in Colorado has always been an interesting milling center, for the ores are, as a rule, complex and require much preliminary experimentation before a suitable flow sheet can be determined. Flotation has simplified the treatment to a considerable degree. The account which follows reviews both mining and ore-treatment conditions and operating mills of the principal districts.*

UNDER the term "San Juan" are grouped the Lake City, Ouray, Silverton, Telluride, Rico, and the Telluride mining districts, including the lower San Miguel River and Naturita vanadium developments. In the last year the San Juan, in common with other districts, has been hampered by high operating costs, scarcity and inefficiency of labor, and the epidemic of influenza. In addition, some plants were shut down and others run at half capacity because of power shortage due to lack of water at the generating stations of the Western Colorado Power Co. This shortage occurs every winter, but last winter it was more severe than usual, some plants being shut down for a month or more. At present, power is sufficient and labor is somewhat more plentiful and efficient, though still not what it used to be. Wages have been reduced slightly—not as much as in other Colorado districts—without strikes. Costs remain about as high as during the war, though a reduction is making itself felt to a moderate extent.

The prospects for the near future are fair, with strong probability for substantial improvement later. Compared with a few years ago, much less ore has been milled during the last year, but the faith of the average operator in the district is unshaken. Many smaller mills will resume in the coming season, and several new plants are about to start operations now. The advance in the price of silver is proving a stimulus which will soon be felt.



MOUNTAIN TOP MINE, PORTAL OF ADIT. MILL IS INSIDE ADIT UNDER RIDGE AT LEFT. ALTITUDE, 12,000 FEET

## Telluride District

The Tomboy, the Smuggler, and the Liberty Bell have been practically the only steady mill operators in the Telluride district. Good ore reserves and efficient management have made it possible for them to run continuously. Some small intermittent operations have also been conducted. The Tomboy mill is operating at 450 tons per day, with practically the same flow sheet as formerly—stamps, amalgamation, concentration, and cyanidation. Much interest is taken in the plans of this company for a new mill. It is the intention to use flotation instead of cyanidation. Construction has already started, and the new plant is expected to be running by next autumn.

The Smuggler Union Mining Co. is operating its mill at Pandora, as usual, and making the customary experiments and continual improvements. The plant receives ores from three mines—the Smuggler, Humbolt, and Black Bear. These ores require separate mill units and railroad cars. The valuable metals are gold, silver, and lead in the case of the Smuggler and Humbolt, and gold, silver, lead, copper, and zinc in the ore from the Black Bear. The ores are all sulphides.

The methods employed are reduction by stamps and in ball mills, with straight flotation on some ores, or concentration on tables followed by flotation on other

*Mining engineer, Ouray, Colorado.

ores. Experiments, consisting of passing flotation froth over tables, are being made, with good results. In other instances the froth is handled by thickeners, pumps, and filters. The flotation machines used are the Callow and Janney, and a Ruth machine is also being put in, from which good results are expected. A new ball mill is now being installed, and it is thought that the tonnage will be increased this summer, by other additions, from the present 450 tons to 700 or 800 tons per day.

The Liberty Bell mill continues to operate at its usual high efficiency, but no great changes are in prospect, the operators asserting that they anticipate a final shutdown soon. This plant has been a training place for a number of well-known metallurgists and mill men of today, and has handled a large quantity of ore. There have been a number of changes, and low-cost records have been made. The ore is gold and silver, associated with pyrite. It is handled by 80 stamps, with Wilfley tables, thickeners, agitators, Moore filters, and zinc-shaving precipitation, the process being concentration followed by the cyanidation of concentrates and mill pulp separately. Despite the cyanidation of concentrate, the extraction is well over 90%. The concentrates are ground to pass 300 mesh for cyaniding, and the mill pulp is ground to 100 mesh. The mill treats 400 to 500 tons daily.

The Belmont-Wagner Co. developed the Alta mine last year and was equipping the mine and finishing the mill when the epidemic of influenza caused the plant to be shut down. Before it resumed operations, the snow forced a delay until this spring. The old mill building was equipped with new machinery, and a first-class mill of 300-ton capacity is now about ready to operate. The ore contains gold, silver, lead, and copper sulphides. The process will be essentially flotation in Jones-Belmont machines, the middling from cleaner cells being treated on tables, which will make a concentrate, the concentrate being reground and sent back into the mill system, and the tailings sent to waste. The ore contains considerable barite, which causes trouble on the tables, but not in the flotation section. This plant will add materially to the output as well as the prestige of the Telluride district, which has always been the busiest part of the San Juan.

The Primos Chemical Co. is building a new plant at Vanadium, on the San Miguel River, a few miles below Telluride, to replace the old plant which burned recently. A steel structure is being erected, and the plant will probably be operating by Aug. 1. The company has never given much information about its plant or method, but it is understood that the process involves roasting and chemical treatment, a chemical product being produced. The ore is vanadium, principally roscoelite, and is obtained largely from the company's own mines near by and to a small extent from small independent producers.

The Colorado Chemical Co., it is understood, will build a plant on the San Miguel River at Sawpit. The company had been shipping vanadium ore to the Primos plant, some of its ore now being stored at that company's mill site, awaiting treatment in the new mill. The Standard Chemical Co. is operating a vanadium plant at Naturita, some distance down the San Miguel River, but no information is available as to its plant or process.

The Ouray district was unusually quiet last year, but is beginning to improve. The former great producer, the Camp Bird, has been developing its mine through the new crosscut adit, and has not operated the mill since September, 1916. No announcement has been made as to resumption of milling, but it is generally expected that milling will be resumed eventually.

The Atlas M. and M. Co., at Sneffels, continues to operate its mill, though at reduced capacity. It is expected that the mill will soon return to its former capacity of 140 tons per day, with possibly an increase in capacity later. This mill, one of the pioneers in flotation in the United States, has been an interesting establishment, and has a record of high recoveries for a period of years. The ore is a low-grade silver and lead, with a small amount of gold and not enough copper to pay for its recovery. Zinc usually accompanies the ore, but has never been a commercial product. It is the intention of the management to experiment with selective flotation. The present treatment is sorting out waste at the head of the mill, followed by breaker, stamps, tables, ball mill, and an eight-cell Minerals Separation machine, followed by a three-cell Hebbard. The first cells make concentrate. From the next cells froth is sent to tables for cleaning, and from the last cells, including the Hebbard, a froth is returned to the head of machine. The flotation feed is practically all through 60 mesh. The lead recovery is high, being approximately 95%. From a mill head of 2.5% lead, a tailing of 0.16 to 0.20% lead is made. The silver recovery is usually slightly over 90%. Variations in the ore cause variations in recoveries.

The Mountain Top Mining Co. is operating its mill at somewhat reduced capacity, but expects soon to resume three shifts. The ore is a good-grade silver-lead, and from it a recovery of 80 to 95% of the silver and a high percentage of the lead, at 48-mesh grinding, is obtained. Mill heads average about 17 oz. silver per ton and 1.5% lead, with a small amount of pyrite, but no zinc or copper. Concentrates vary in grade, but average about 130 oz. silver per ton, 17% lead, 15% silica, and 25 to 30% iron. The mill has a capacity of 50 tons per day. The equipment consists of a crusher, a ball mill and a flotation machine. The froth is cleaned on a table and the tailing passed over a pilot table.

The mill is interesting because of the fact that it is underground. It is situated at about 1500 ft. from the portal of the adit through which the mine is operated. The arrangement is a series of rooms staggered on either side of a central incline, a separate room being provided for each machine. The mill operator in one room can see the machine in the opposite room on the next lower level. The ore is raised from the tunnel level through a vertical raise by an automatic elevator to a bin which is simply a chamber in the rock.

The mill operated all winter, despite the fact that it is situated at 12,000 ft. altitude, in a region of heavy snowfall. No heating is required. Tailing is run to the portal of the adit by means of a 2-in. centrifugal pump and 2-in. pipe line, which never clogs. As an interesting example of hit-or-miss trials in flotation, it is reported that the flotation machine at times failed to make a froth, and no reason could be found. Various reagents were tried, with varying success, until someone tried a small amount of spent carbide from the miners' lamps. This is said to have been an unfailing remedy, causing the froth to form quickly.

These two are the only mills that are operating steadily in this district. The Barstow mill, as usual, will operate

this summer, when water from the gulch becomes available from melting snow. High-grade gold ore will be handled during the summer. The Red Mountain Mines Co. will probably operate a small mill later in the year at the old Genessee mine. The Gold Crown mill, at Ouray, which was remodeled and put in good condition last autumn, for the purpose of treating a variety of ores as a custom plant, may be started this summer, as well as the mill of the Vernon Mining Co. at Ironton, under the same management.

The Ouray Con. M. and R. Co. is finishing a new mill at Ironton. This is the only mill so situated that it can serve the Ironton district, and it is expected that its operation, as a custom plant, will stimulate mining in that region. The plant is well designed, as a one-mineral mill, including classification, coarse tables, and flotation, with regrinding and further concentration if necessary. The same company plans to operate the old Treasury mill, at Red Mountain, late in the year, on ore from the National Belle.

### Silverton District

The Silverton district has been retarded more than any of the others because of general conditions, especially the epidemic of influenza, but seems to be "coming back" as well as the other districts. Practically all milling operations have been in the mills close to Silverton. A year ago the A. S. and R. Co. operated a flotation plant at the company's Durango smeltery, in an experimental way, principally on San Juan concentrates, but has not continued this work recently.

At present the Iowa-Tiger mill is operating; the Gold King is making extensive improvements and practically building a new mill; the North Star mill will probably be in operation later, and the Contention property has been taken over by new interests, with the expectation of doing considerable mill improvement, as well as of operating the mill. Flotation in combination with table concentration is generally practiced.

The most interesting mill operation in the district, if not in the whole San Juan, is the mill of the Sunnyside M. and M. Co. This company bought the famous Sunnyside mine some time ago and spent a large sum of money in equipping both mine and mill. The plant was put in operation, but great difficulty was experienced on account of the labor supply. Last March, when conditions were improving, the entire mine plant burned. Construction of new plant has begun, and it is expected that the mill will resume in three or four months.

The ore is the usual San Juan sulphides, intimately mixed with a quartz and rhodonite gangue. The rhodonite is abundant, the ore having the average content of 7% manganese. The process is straight flotation, with selection into lead and zinc concentrates, most of the pyrite going into the lead concentrate. The success of selective flotation at this plant has attracted much interest. The capacity of the mill is 500 tons, with the following flowsheet:

No. 6 Gates gyratory crushers at mine to 3 in.; Trenton cable tram 16,000 ft. to mill; Merrick weightometers to three 30-ft. cylindrical steel bins, 4000-ton capacity; 8 by 6-ft. Marcy mills, closed circuit 6-ft. Dorr classifiers to 28 mesh, with 40% through 200 mesh; 5 by 14-ft. tube mills and a 5 by 8-ft. ball mill, closed circuit with classifiers, to 48 mesh, with 65 to 70% through 200 mesh; lead flotation in 14-cell M. S. machine, eight standard and six Hebbard sub-aërated cells—producing final lead. Zinc flotation in 29-cell standard M. S. machine (both M. S. machines 24 in.); the lead concentrate, zinc concentrate, and tailing pass to six tables, which make no cuts, but are used simply as pilots, though not used continuously. Final tailing to two 40-ft. Dorr thickeners for water recovery in winter; the two concentrates to separate Dorr thickeners; thence to Portland filters; thence to steel bins, and by gravity to railroad cars.

The gross recovery, figured on the value of all metals recovered, is 90 to 92%. The Marcy mill requires 2¼ lb. of chrome-steel balls and 0.7 lb. manganese-steel liners per ton ground, and 200 hp. when one mill is grinding 350 tons per day. In the tube mills selected rhodonite from the mine is used in an amount equal to twice as much as would be required if imported pebbles were used. The 5 by 8-ft. ball mill uses 2-in. manganoid balls and grinds 50% more, with 35% more power, than the tube mills using rhodonite, but the tube mills are favored on account of costs. The first head sample is taken automatically from the tube-mill overflow. The concentrate plant is built large enough to handle all the concentrate on one shift, thus allowing longer settling and thickening in the Dorr apparatus, with the result of lower moisture content. The lead concentrate is discharged from the thickeners at 35% moisture and from the filters at 6½%; the zinc concentrate at 40% and 7½% respectively. These moistures are so satisfactory that the drier bought for the concentrates is not used.

The total power used, including the crushing plant, when handling 550 tons per day, is 900 hp. The lead concentrate assays 50% lead and 13% zinc; the zinc concentrate, 50% zinc and 6% lead. The normal mill crew, excluding the crushing and concentrate handling plants, is five men per shift, including a shifter.

## Fine Crushing in Idaho

According to a preliminary report recently issued by the Bureau of Mines on the mining districts of Idaho, in order to crush material such as middlings and tailings from jigs and tables to a size suitable for table concentration and for flotation, some type of pebble or ball mill is generally used. Both cylindrical and conical types are used in the mills of the district, and both types are found in some mills.

The ore in the ball mills is crushed wet, the mixture varying from about two parts of ore to one part of water to one part of ore to two parts of water. It is believed that the lower water content would result in more efficient crushing in the long run, depending, of course, upon the amount of slimes the mill man desires to produce. In general, more water is required for a granular product than for the production of a slime. Also, the proportion of water used has considerable effect on the capacity of the ball or tube mill.

However, each individual problem must be worked out to obtain the greatest crushing efficiency in the ball mills, according to the conditions of operation and the kind of product desired.

Ball or tube mills, when used for fine crushing, are usually in closed circuit with classifiers, the oversize being returned to the tube mill and the overflow either passing to Dorr thickening tanks for flotation or to cones or hydraulic classifiers for subsequent treatment on tables. The sizes of cylindrical ball mills commonly used are 5 by 5, 5 by 10, and 6 by 14 ft.; the conical type of Hardinge mills are usually 6 ft. by 22 in., although smaller and larger sizes are found in some of the mills.

# Shafting and Belting

By ROBERT S. LEWIS*

*Associated with data relating to the design of belts and shafting to be used in ore-dressing and milling plants there is a confusing superabundance of formulas, charts, and rules, from the use of which widely divergent results may be obtained. In this article the author has attempted to select the smallest number of reliable formulas and charts that would solve the problems ordinarily encountered. The mathematical analysis of the design of shafting is entirely satisfactory. However, the mathematical analysis of the action of belting is impossible without making assumptions regarding the value of certain quantities, and these conclusions must rest on experimental data if the formulas derived are to be of practical application. The data on belting that are included in the following paper seem to be the most reasonable combination of theory and practice that is warranted by the present knowledge of the subject.*

THE numerous and long lines of shafting, all driven by a single prime mover, which were so common in milling plants of earlier design, have been greatly reduced in number in modern installations by the introduction of the individual motor drive for machines. However, the proper diameter of shafts and the spacing of bearings are still important questions, as is shown by the excessive vibration and not infrequent breakage of shafting in mills of comparatively recent design.

Few shafts are subjected only to simple twisting. Pulleys and gears exert a lateral pressure on shafts and often cause severe bending stresses. As the direction of the line of action of these forces remains fixed, it is plain that during one revolution of a shaft the stress at any point will change from maximum compression to maximum tension. Moreover, the operation of such machines as crushers, ball mills, and rolls, which, of necessity, make irregular demands on the power supply, throws a rapidly fluctuating intensity of load upon the power-transmission machinery. For these reasons, shafting should be made of tough and ductile material, well adapted to withstand shock and severe service.

Wrought iron was formerly often used for shafting in mill operation, especially in the manufacture of the camshafts for stamp mills, but its tendency to crystallize and break, the high cost of manufacture, and its lesser strength have led to its replacement by steel. Bessemer steel, of the so-called "mild grades," is sufficiently tough and ductile to be suitable for use as shafting. It is now the most widely used material for this purpose. Openhearth steel is more uniform and reliable than bessemer steel, and is often specified for important parts of certain machines, such as spindles for machine tools and armature and engine shafts. In the case of automobiles and marine engines, where great strength and toughness are desired, special alloy steels, such as those containing nickel, tungsten, manganese, chromium or vanadium, are used. These alloys are more expensive than common grades of steel, and, though stronger, they have no greater rigidity.

Classified according to the method of manufacture, shafting is known either as cold-rolled or turned. Turned shafting is made by rolling the hot steel ingot to a diameter about $\frac{1}{16}$ in. larger than that of the finished shaft. It is then placed in a lathe, turned down and polished to exact size. Large shafts are forged from an ingot and then finished by turning. Turned shafting is used for high-grade machinery, where great accuracy of size is required. In the cold-rolling process, the hot ingot is first rolled in the manner just described, after which it is treated with acid to remove the adhering scale. It is then passed cold through special rolls under heavy pressure. No scale is formed by this cold rolling. The finished shaft has a bright, smooth, and hard surface and is accurate in diameter. The elastic limit and ultimate strength of the steel are increased, but its ductility is decreased. Most of the shafting used for power-transmitting purposes is made by this process. The sizes carried in stock by manufacturers range from $\frac{3}{16}$-in. to 5-in. diameter by increments of $\frac{1}{16}$ in., and in lengths from 1 to 24 ft., the larger sizes being made to order.

The weight of steel shafting may be calculated with sufficient exactness for all practical purposes by the formula:

$$W = 2.67\ d^2\ L \qquad (1)$$

Where, $W$ = weight in pounds.
$d$ = diameter in inches.
$L$ = length in feet.

Wrought-iron shafting averages in weight about 2% lighter than steel.

Shafting may be subjected, depending upon its use, to simple bending, simple twisting, combined bending and twisting, or combined twisting and compression. In instances of simple bending (without twisting) the shaft may revolve, as in the case of a car axle; or it may be stationary, as when used as the shaft for a crane or hoisting drum. If the external and internal bending moments are equated and reduced to the lowest terms, the following formula for simple bending is obtained:

$$d^3 = \frac{10.2\ M}{S} \qquad (2)$$

Where, $d$ = diameter in inches.
$M$ = external bending moment in inch-pounds.
$S$ = safe unit bending stress in pounds per square inch.

Mild steel used for shafting has an elastic limit of approximately 35,000 lb. per sq.in. Using a factor of safety of from 5 to 10, the value of $S$ would range from 7000 to 3500 lb. per sq.in. For calculating the deflection of such a shaft, the coefficient of elasticity, $E$, is taken as 29,000,000, and the deflections are determined in the same manner as for round beams.

A long shaft carrying a pulley at each end, or with several pulleys close to bearings, is often considered as being subjected to simple twisting only. Though this assumption may be safe enough for light loads, shafts transmitting large amounts of power and carrying large pulleys should be designed to withstand both twisting

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and bending stresses. For round shafts, considering twisting only, the following formula applies:

$$T = P \times R = M_t = \frac{3.1416\, d^3\, S_t}{16} \text{ or } d^3 = \frac{5.1\, T}{S_t} \quad (3)$$

Where, $T$ = applied twisting moment in inch-pounds.
$P$ = load in pounds applied at end of arm $R$.
$R$ = length of lever arm in inches.
$M_t$ = internal torsional or twisting moment in inch-pounds.
$S_t$ = safe unit shearing stress in pounds per square inch.
$d$ = diameter of shaft in inches.

Expressing $T$ in terms of horsepower, hp., and revolutions per minute, $n$,

$$T = \frac{63{,}030\, hp.}{n} \quad (4)$$

and substituting in (3),

$$d^3 = \frac{321{,}000\, hp.}{n\, S_t} \quad (5)$$

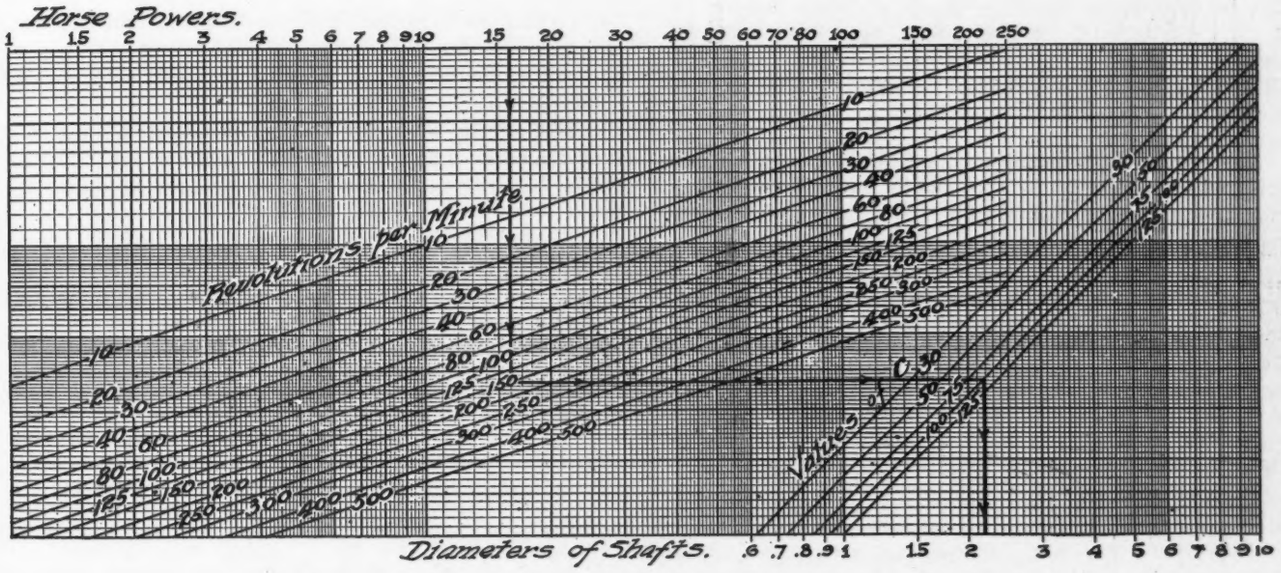



CHART 1. SHAFT DIAMETERS FOR GIVEN HORSEPOWERS AND SPEEDS

Practical experience has indicated how this formula may be modified to apply to shafting that is working under different conditions of operation. Several manufacturers recommend the values of $S_t$ given below.

For well-supported head shafts, carrying main driving pulleys, sheaves, or gears, and transmitting heavy loads, $S_t = 2600$ and

$$d^3 = \frac{125\, hp.}{n} \quad (6)$$

For regular line shafts, supported on bearings every 8 ft., $S_t = 4300$ and

$$d^3 = \frac{75\, hp.}{n} \quad (7)$$

For light-duty line shafts supported on bearings every 8 to 10 ft., $S_t = 6400$ and

$$d^3 = \frac{50\, hp.}{n} \quad (8)$$

Different designers will use other values of $S_t$ than those given above, in accord with the refinement of calculation that they wish to make, but the values stated are conservative rather than otherwise. Chart 1, taken from the catalog of the Robins Conveying Belt Co., gives a quick graphic solution of the problem for a number of values of $C$, corresponding to 125, 75, and 50 in the equations stated. The solution given is for 16 hp. at 150 r.p.m., and shows that for $C = 100$, a $2\frac{3}{16}$-in. shaft would be required. The diameter of shafting is always given in the nearest sixteenth of an inch.

Though shafts may be strong enough for the work they are to do, they may not have sufficient torsional stiffness to prevent considerable twisting or winding up of the shafts around their own axes. This is of no practical importance for the common conditions of power transmission, but it is of importance in the case of machine tools which are doing careful work, as there must be no lagging in the operation of the machine. Several authorities state that the angular deflection should not be permitted to exceed 0.08° per ft. of length of shaft. The requisite stiffness is obtained by using the following formula to design the shaft diameter.

$$d = 4.6 \sqrt[4]{\frac{hp.}{n}} \quad (9)$$

The torsional deflection of any shaft may be found by the formula:

$$\theta = \frac{584\, T\, L}{d^4\, E_t} \quad (9a)$$

Where
$L$ = length in inches of shaft.
$d$ = diameter of shaft in inches.
$T$ = twisting moment in inch-pounds.
$\theta$ = angle of deflection in degrees.
$E_t$ = torsional coefficient of elasticity, commonly taken as 12,000,000.

In case a shaft carries large pulleys or gears, its strength in regard to bending should be investigated. Formula (6) will give a diameter that is sufficiently safe for nearly all cases, but for extra heavy loads it is necessary to take both twisting and bending moments into consideration. There are several formulas in use which combine these two moments. A convenient one, especially in the graphic form shown in Chart 2, is given by J. H. Barr[1]. The bending and twisting moments are combined into a single moment called the equivalent twisting moment. This moment is con-

[1] *American Machinist*, June 11, 1908.

sidered as causing the same unit stress in the shaft as would be set up by the separate bending and twisting moments acting together.

$$M_e = M + \sqrt{M^2 + M_t^2} \qquad (10)$$

Where

$M_e$ = equivalent twisting moment.
$M$ = applied bending moment.
$M_t$ = applied twisting moment.

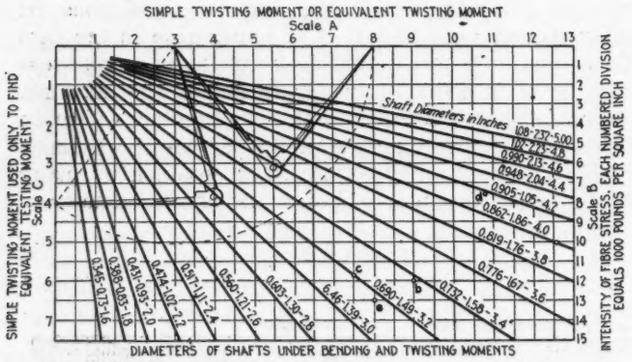

SIMPLE TWISTING MOMENT OR EQUIVALENT TWISTING MOMENT
Scale A
SIMPLE TWISTING MOMENT USED ONLY TO FIND EQUIVALENT TESTING MOMENT Scale C
INTENSITY OF FIBRE STRESS, EACH NUMBERED DIVISION EQUALS 1000 POUNDS PER SQUARE INCH
Scale B
Shaft Diameters in Inches
DIAMETERS OF SHAFTS UNDER BENDING AND TWISTING MOMENTS

CHART 2. DIAMETERS OF SHAFTS UNDER BENDING AND TWISTING MOMENTS

The equivalent twisting moment, $M_e$, can now be substituted for either $M_t$ or $T$ in one of the forms of Equation (3), and, assuming a value for $S_t$, the equation can be solved for the value of $d$. As $T$ and $M_t$ have the same numerical value, Equation (4) gives the value of $M_t$, and the applied bending moment, $M$, must be found by calculations to be explained later. Chart 2 may be utilized in several ways, as follows:

Scale $B$ always has the same value for each division, namely 1000 lb. per sq.in. Scales $A$ and $C$ must each have the same value per division, but this value may vary with conditions, being 100, 1000, or 10,000, as the case demands. Thus, the readings on scales $A$ and $C$ for the first position of the compasses may be 300 and 400, 3000 and 4000, or 30,000 and 40,000 respectively. The three sets of shaft diameters given on the diagonal lines correspond with the low, medium, or high values taken for the scale divisions. The range of the chart may be increased by taking the divisions as equal to 100,000 or 1,000,000 inch-pounds. Then the lowest and intermediate values of shaft diameters should be multiplied by 10 to give corresponding results.

1. To find the required diameter of a shaft for a given twisting moment and fiber stress: Erect perpendiculars from scales $A$ and $B$ at the points corresponding to the given values and find their intersection. If this comes on a diagonal, the required shaft diameter is given at once. If the point does not fall on a diagonal, the required diameter may be found by interpolation.

2. To find the intensity of stress for a given shaft and twisting moment: From the given twisting moment on Scale $A$, drop a perpendicular to the diagonal or interpolated point for the given size of shaft. Then pass horizontally to cut Scale $B$. This point gives the desired intensity of fiber stress.

3. To find the twisting moment that will produce a given fiber stress in a shaft of a given diameter: From the fiber stress on Scale $B$ pass horizontally to the diagonal, or interpolated point, of the given shaft diameter. Then go vertically to cut Scale $A$. This point gives the desired twisting moment. Use the proper value of scale divisions according to the size of shaft given.

4. To find the required diameter of a shaft for a given bending moment and intensity of fiber stress: Multiply the bending moment by 2, use this result to enter Scale $A$, and proceed as under 1.

5. To find the intensity of fiber stress in a shaft of given diameter under a given bending moment: Multiply the bending moment by 2 and proceed as under 2, above.

6. To find the bending moment in a shaft of given diameter when the fiber stress is known: Proceed as under 3, above. Divide the moment thus found by 2 and the result gives the desired bending moment.

7. To find the diameter of a shaft for combined bending and twisting moments: Lay out the bending moment on Scale $A$ as outlined for the twisting moment under 1. Lay out the twisting moment on Scale $C$, using the same value per division. Set compasses or dividers to the length between these points (3-4 on the chart) and pivot the dividers on Scale $A$ to cut a new point further out on this scale, as at 8. This gives the value of the combined moments. Then proceed as under 1.

8. To find the fiber stress for a given shaft acted upon by combined bending and twisting moments: Find the equivalent moment as under 7. Then find the fiber stress as outlined under 2.

A method of determining the bending moment for a shaft is as follows:

In Fig. 1 a shaft is supported by bearings at $M$ and

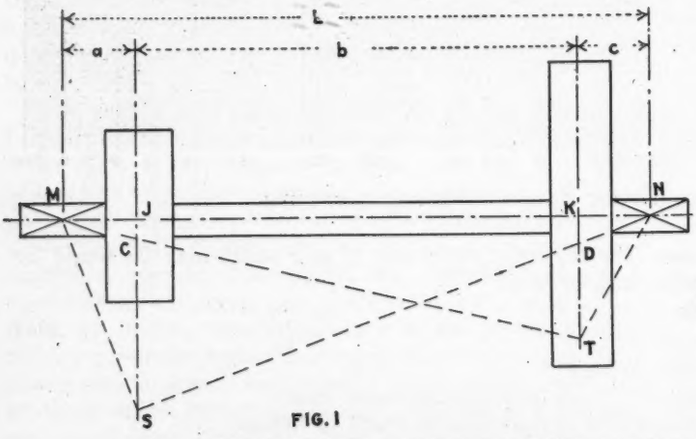



FIG. 1

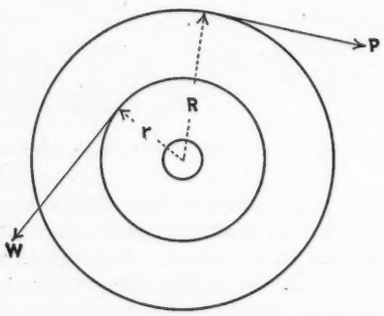



FIG. 2

FIG. 3

DIAGRAMMATIC METHOD OF DETERMINING BENDING MOMENTS OF SHAFTING

$N$ and carries two pulleys. The directions of the pull of the belting are shown in Fig. 2. The horsepower and number of revolutions per minute for each pulley being known, it appears that from (4) $T = 63{,}030\ \frac{hp.}{n}$ and from (3) $T = M_t = P \times R = W \times r$, ($W \times r$ will be less than $P \times R$ if all the power applied at $P$ is not taken off at $W$, but, in any case, the actual horsepower transmitted by the smaller pulley is known), from which the values of $P$ and $W$ are easily found. But $P$ and $W$ are the net belt pulls. If $T_1$ is the total tension in the tight side of a belt, and $T_2$ is the total tension in the slack side of the belt, the net pull is $T_1 - T_2$. Now, the total pull exerted on the shaft by the belt is obviously $T_1 + T_2$ and this is much greater than the net pull. Without discussing here the question of belts, the average relation between the tensions in usual cases of power transmission has been given as $T_1 = 2T_2$, which makes $T_1 + T_2 = 3$ times the net pull. Therefore $P$ and $W$ should be multiplied by 3 to get the total pull causing deflection of the shaft. The relation between tensions is meant to be an average figure, and it is not intended that this value should be considered as a fixed and invariable one. However, it will give a more reasonable diameter of shaft than if the net pull is used in the designing.

The bending moments caused by these forces should be calculated by the formulas for the bending moments for beams which are to be found in nearly all engineering handbooks. The most complete set of tables is published in *Machinery's* Handbook and deserves special mention because of its completeness. The general expression for the maximum bending moment caused by a single load is $M = \frac{W a b}{L}$, where $W$ is the load in pounds, $a$ and $b$ are the distances from load to supports, and $L$ is the span, expressed in inches. For the two pulleys, then, $\frac{W \times a \times (b + c)}{L}$ and $\frac{P \times c \times (a + b)}{L}$ represent the maximum bending moments. Construct the moment diagram for each pulley by laying off $J$-$S$ and $K$-$T$ perpendicular to the axis of the shaft and representing the value of the bending moments to some convenient scale. Connect the points $S$ and $T$ with the bearings $M$ and $N$. The span of the shaft is measured to the center of the bearings. Then, $M$-$S$-$N$ is the moment diagram for the smaller pulley due to $W$, and $N$-$T$-$M$ is the moment diagram for the larger pulley due to $P$. Also, $J$-$C$ and $K$-$D$ are the moments caused at the center of one pulley by the force acting upon the other pulley, and the total moment at each pulley is the sum of its own moment and the moment caused by the other pulley. It is evident that the greater combined moment is at the smaller pulley, but these moments cannot be directly added, as their lines of action differ in direction. They must be combined by vector addition. In Fig. 3, $J$-$C$ and $J$-$S$ are the two moments, drawn to scale and parallel to the forces $P$ and $W$. Their geometrical sum in magnitude and direction is $C$-$S$. (To avoid possible confusion, it should be noted that this $C$-$S$ is not the same as the distance $C$-$S$ in Fig. 1.) This bending moment is now combined with the applied twisting moment due to $P$ in the manner explained under 7 for Chart 2.

To prevent excessive vibration, the limit of lateral deflection is often placed at 0.01 in. per ft. of shaft. The handbooks, referred to above, give formulas for calculating deflections. For shafting, the value of the coefficient of elasticity for bending should be taken at 29,000,000 and the moment of inertia, $I$, is $0.0491\ d^4$. The deflection curve for each pulley should be plotted, and the two deflections should then be combined by vector addition in the same manner as explained for bending moments. If the total calculated deflection is greater than 0.01 in. per ft. of shaft, the diameter must be increased. To minimize bending stresses, pulleys should be placed as close as possible to the bearings.

The effect of keyseats in a shaft has been studied by Prof. H. F. Moore[2], who found that the ultimate strength of a shaft with keyseats is practically the same as for a solid shaft, irrespective of the length of the keyseats, but the elastic strength of a shaft with keyseats is noticeably affected. He proposes the following formula:

$$k = 1.0 + 0.4w + 0.7h. \qquad (11)$$

Where

$k$ = ratio of angle of twist of a shaft with keyways to angle of twist of a similar shaft without keyways.

$w$ = width of keyway divided by diameter of shaft.

$h$ = depth of keyway divided by diameter of shaft.

In general, keyways are about one-quarter of the diameter of the shaft in width, and their depth is from five-eighths to three-quarters of the width.

Keyseating tends to spring a shaft out of line, and this is especially true for cold-rolled shafting, which has a tough outer skin. Manufacturers usually straighten all shafts up to 6-in. diameter after keyseating. Larger sizes are keyseated and then turned to size. Shafting can be straightened by bending slightly, over a support, in a direction opposite to that in which the shaft is sprung, and then striking with a sledge on the upper part of the shaft. This stretches the metal and straightens the shaft. The striking must be carefully controlled, as it can easily be overdone. To protect the surface of the shaft from injury, the blows of the sledge may be made to fall on a piece of metal, of proper curvature, placed on the shaft.

The power lost through friction in bearings cannot be satisfactorily estimated by any formula. Kent[3] states that the friction loss in line shafts ranges from 3.3 to 11.4%, with 5% as an average. Published data from tests show losses ranging from 40 to 75%. These large losses occur in factories having long lines of shafting driven by a single prime mover. Tight belts throw an undue strain on bearings, and the settling of hangers throws a shaft out of alignment. Such conditions are doubtless the cause of a large part of the losses just mentioned. The use of individual drives has greatly reduced the length of shafting driven by a single prime mover, and for shafting that is kept in good alignment and making use of ring oiling bearings, the frictional losses should not exceed the figures given by Kent. Practically no data have been published on the subject of friction loss in shafting in milling plants, but this would seem to be an interesting question.

## Notes on Belting

In Fig. 4, let the belt be running in the direction indicated, and let $T_1$ be the total tension in the tight or driving side and $T_2$ be the tension in the slack side of

[2] *Bulletin* 42, University of Illinois Experiment Station.

[3] "Mechanical Engineer's Pocket Book."

the belt. Then the net effective tension for transmitting power is

$$T = T_1 - T_2 \qquad (12)$$

For a belt at rest the tension is considered to be uniform throughout the length of the belt and is called the initial tension, $T_o$.

The early conception of the operation of belts was that the sum of the tensions $T_1$ and $T_2$ remained constant at all speeds, and the following formula for the relation of these tensions was derived,

$$T_1/T_2 = 10^{0.00758fa}{}^{4} \qquad (13)$$

where,

$f$ = the coëfficient of friction.

$a$ = angle of contact in degrees of belt on smaller pulley.

It was found by sliding a leather belt over stationary pulleys that the coefficient of leather on iron was approximately 0.42. Under these conditions the problem of

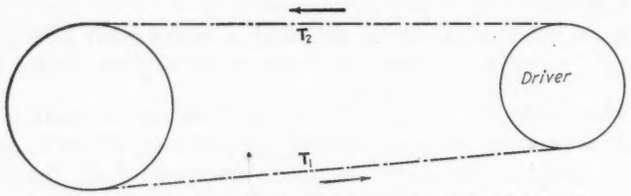



FIG. 4. DIAGRAM SHOWING DIRECTION OF BELT DRIVE AND TENSIONS

belt design appeared to be simple. The horsepower to be transmitted being known, the net or effective pull could be found from equations (3) and (4). The values of $f$ and $a$ were calculated and substituted in Equation (13). Then from Equation (12) the values of $T_1$ and $T_2$ could be found. The breaking strength of belt material was known, and by using a reasonable factor of safety it was possible to determine the maximum tension, $T_1$, to which a belt should be subjected. However, experiments by Lewis and Bancroft upset all previously accepted ideas in regard to belting by proving that the sum of the tensions, $T_1$ and $T_2$, did not remain constant, but changed with the condition of the belt and pulley surfaces, the speed and slip of the belt, until, as one writer stated, the coefficient of friction $f$ might as well be considered as $x$, because it was such a variable quantity.

F. W. Taylor[5] carried on a series of experiments with belts in machine shops. His work covered a period of about nine years, and had for its object the securing of the longest economic service from belts by running them under carefully regulated tensions and standardizing conditions of upkeep and repair. Belts were put on pulleys under definite initial tension by means of spring balance clamps, and were retightened to the original tension whenever they stretched so that they began to wave or flap or showed signs of slipping.

Consider a belt under an initial tension $T_o$. As soon as the belt moves and power is transmitted, the tension in the tight side of the belt increases while that in the slack side decreases, until the difference—the net or effective pull—is sufficient to transmit the desired horsepower. It is evident that the tension in the tight side of the belt may be much greater than the initial tension, $T_o$, and that $T_1$ is greater than the effective pull by $T_2$. Depending upon the value of $T_2$, the unit stress in the tight side of the belt may become dangerously great, if the belt is designed only for withstanding the net or effective pull. Obviously, a formula for computing the horsepower of belting of the form

$$hp. = \frac{\text{effective pull in lb.} \times \text{speed of belt in ft. per min.}}{33{,}000}$$

gives no information about the maximum stress to which a belt may be subjected. If modified to the form

$$hp. = \frac{\text{width of belt in in.} \times \text{thickness in in.} \times \text{safe pull per sq. in. of belt} \times \text{speed of belt}}{33{,}000}$$

there is still no way of showing to what value $T_1$ might attain. The only certain point is that a belt so designed will be under more than a safe stress. A number of formulas of this kind are in use. They are almost entirely empirical in nature and some give widely divergent answers.

Taylor used the records of initial tension, power transmitted, and life of belts as data for calculating the approximate working tensions to which the belts had been subjected, and he then formulated certain recommendations for installing leather belts. He suggests from 4000 to 4500 ft. per min. as the best speeds for belts. The distance between shafts should be from 20 to 25 ft. Not less than a 12-in. pulley should be used for double belts. The minimum pulley diameters for triple and quadruple belts should be 20 and 30 in., respectively. A double leather belt should be under an initial tension of 71 lb. per in. of width. With an arc of contact of 180°, this tension will give an effective pull of about 35 lb. per in. of width of belt. As a general rule, a double belt 1 in. wide should run at a speed of 950 ft. per min. to transmit 1 hp. Such a rule required the use of heavier and, therefore, more expensive belts than would be used under the old empirical formulas. Whether a belt is to give the longest possible life with the minimum of repairs, or is to be operated under the maximum stress that it can bear, is a problem that the designer must solve in accordance with the conditions imposed. The first condition involves high first cost but minimum cost for repairs and renewals; the second, least first cost for belting, but high cost for repairs and renewals.

C. G. Barth[6] has made a careful study of the work of former writers on belting, and has proposed formulas and rules for designing leather belts. He gives an extensive mathematical analysis of the question, starting with Formula 13 as a basis for calculations. However, he has to make several assumptions in order to reach his conclusions. The coefficient of friction is considered to vary with the belt speed, or

$$f = 0.54 - \frac{140}{500 - V} \qquad (14)$$

where $V$ is the belt speed in ft. per min. He states that leather is an elastic material, and recognizes the modifying effect on the tensions that centrifugal force exerts in a belt traveling at high speed. Thus

$$T_c = \frac{w}{300\,g} V^2 \qquad (15)$$

where

$T_c$ = loss in effective tension per sq.in. of belt cross-section.

$w$ = weight in lb. of 1 cu.in. of leather.

$g$ = 32.2, acceleration due to gravity.

$V$ = velocity of belt in feet per minute.

[4] Rankine's "Machinery and Mill Works," p. 351.

[5] "Notes on Belting," *Trans.* Am. Soc. Mech. Engs., Vol. 15, p. 204.

[6] "The Transmission of Power by Leather Belting," *Trans.* Am Soc. Mech. Engs., Vol. 31, p. 29.

The effect of centrifugal force is to lessen the effective tension in a belt: consequently, no advantage is to be gained from running belts at speeds greater than about 4500 ft. per minute.

Equation 13 now becomes

$$\frac{T_1 - T_c}{T_2 - T_c} = 10^{0.000758/a} \qquad (16)$$

His further assumptions are that, for a belt driving a machine, the minimum initial tension must be such that, when a belt is doing its maximum amount of work, the sum of the tension in the tight side of the belt and one-half that in the slack side should equal 240 lb. per sq.in. of cross-section for all speeds. For countershafts, where it is not convenient to retighten belts often, the sum of the tensions should be 160 lb. Also, the maximum initial tension to which a belt should be retightened as often as it drops to a minimum, as defined above, should be 320 lb. for a machine belt and 240 lb. for a countershaft belt.

Mr. Barth has constructed an elaborate chart for the solution of belt problems, from which the following table is derived.

TABLE I. BELT FUNCTIONS DERIVED FROM CHART

| | Machine Belts $T_1 + \frac{1}{2} T_2 = 240$ Pounds | | | | | | Countershaft Belts $T_1 + \frac{1}{2} T_2 = 160$ Pounds | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V$ | 500 | 1000 | 2000 | 3000 | 4000 | 5000 | 500 | 1000 | 2000 | 3000 | 4000 | 5000 |
| $T_0$ | 124 | 120 | 121 | 128 | 136 | 144 | 82 | 81 | 83 | 89 | 96 | 102 |
| $T_c$ | ... | 3 | 13 | 31 | 56 | 86 | ... | ... | ... | ... | ... | ... |
| $T_1$ | 210 | 212 | 211 | 207 | 198 | 187 | 140 | 141 | 140 | 134 | 125 | 114 |
| $T_2$ | 60 | 54 | 57 | 68 | 84 | 107 | 40 | 38 | 41 | 53 | 69 | 92 |
| $T_1 - T_2$ | 150 | 158 | 154 | 139 | 114 | 80 | 100 | 103 | 99 | 81 | 56 | 22 |
| $T_1 + T_2$ | 270 | 268 | 269 | 274 | 282 | 294 | 180 | 179 | 181 | 187 | 194 | 206 |
| Horsepower per sq.in. of section | 2.27 | 4.79 | 9.33 | 12.64 | 13.8 | 12.1 | 1.51 | 3.12 | 6.04 | 7.36 | 6.79 | 3.33 |

As the data are for 1 sq.in. of belting, the total cross-sectional area of a belt is found by dividing the required horsepower of the belt by the horsepower transmitted per square inch of section, as stated in the table. The thickness of the belt is decided upon, and the width is then computed from the sectional area.

A mathematical analysis of the power of belting cannot be made without the aid of some such assumptions as have been given. These assumptions are reasonable averages based upon recorded experience with belts, and the rules derived go far toward placing the question of belt circulations on a more rational footing than when purely empirical formulas are used for designing belts.

C. J. Morrison[7] states that experience with thousands of leather belts over a period of several years in different factories indicates that the simple formula given below is entirely satisfactory for designing belts. Two constants must be known: the square feet of belting passing over the pulley in a minute and the speed of the belt in feet per minute. These constants are 80 and 3000, respectively, for double belts, and 160 and 3000 for single belts. Then

$$W = \frac{F \times hp. \times 180}{V \times \theta} \qquad (17)$$

where

$W$ = width of belt in feet.
$hp.$ = horsepower transmitted.
$F$ = square feet of belt passing over pulley per minute.
$V$ = speed of belt in feet per minute.
$\theta$ = are of contact in degrees of belt on smaller pulley.

The assumption that the formula makes regarding the angle of contact is not strictly correct, but it has less variation from correct results than there is variation in the manufacture of belts. The best belt speed is 3000 ft. per min. The following formula may be used to find the arc of contact on the smaller pulley, when the pulley diameters and distance between centers are known:

$$\theta = 180 - 115 \frac{(r_1 - r_2)}{c} \qquad (18)$$

where

$\theta$ = arc of contact in degrees.
$r_1$ = radius of larger pulley in inches.
$r_2$ = radius of smaller pulley in inches.
$c$ = distance between centers in inches.

The proper initial tension for belts is obtained by shortening the exact measured length by 1 in. for each 10 ft. of length. The width of pulleys for straight belts up to 16 in. wide should be 25% greater than that of the belt, for wider belts from 15 to 25% greater, and for crossed belts 30 to 35% greater. However, these widths will be considered extreme by those who have been accustomed to use pulleys only one or two inches wider than belts and have found such pulleys to give satisfactory service. Pulleys should be crowned uniformly with a well-rounded top, to prevent shifting of the belt across the pulley face. The usual crowning is from $\frac{1}{16}$ in. to $\frac{1}{8}$ in. per ft. of width.

The best leather for belts is cut from the central part of the hide. Pieces should not be more than 4½ ft. long, as a greater length would include the neck of the hide, a part that stretches easily and does not make good belts. The strips are sewed, cemented, or riveted together to make a belt of requisite thickness and width. Hides are tanned in different ways, the two most common being the oak-tan and the chrome-tan processes. Chrome-tanned leather is to be recommended where there is danger of the belt coming in contact with steam or moisture. Oak-tanned leather is for indoor use, where the belt is protected from both water and steam. The chrome-tan process is more or less secret, but produces a leather that is very durable, because the fibrous structure of the leather is preserved in unweakened condition. Leutwiler[8] states that the ultimate strength of oak-tanned leather ranges from 3000 to 6000 lb. per sq.in., according to grade, but that the ultimate strength of chrome-tanned leather varies from 7500 to 12,000 lb. per square inch.

The average weight of leather belting is about 0.035 lb. per sq.in. First-class leather belts should show a tensile strength of not less than 4200 lb. per sq.in. of leather or at splice. The elongation should not be more than 12.5% in 2 inches, 1 in. on each side of break, or less than 8% elongation at breaking strain. When at full length a leather belt should lie flat on the floor with practically no curvature; otherwise the belt will not run true on the pulleys. Belts should be well stretched before using, so that they will not require taking up every few days after they are first put on the pulleys.

[7] "Belts, Their Selection and Care," *Engineering Magazine*, July 1916.

[8] O. A. Leutwiler, "Machine Design."

Leather belts are classified as single, double, triple, and quadruple, according to their variation in thickness as compared with that of a single hide. There are graduations in each class, as is shown in Table II, which gives the thickness and weight of the different grades.

TABLE II. THICKNESS AND WEIGHTS OF DIFFERENT GRADES OF BELTS.

| Weight, oz. per Sq. Ft. | Thickness in Inches. | Weight, oz. per Sq. Ft. | Thickness in Inches |
|---|---|---|---|
| Single | | Triple | |
| 9 | 1/8 | 35 | 15/32 |
| 12 | 5/32 | 37 | 1/2 |
| 14(a) | 3/16 | 40(a) | 17/32 |
| 16(a) | 7/32 | 42(a) | 9/16 |
| 19 | 1/4 | 44(a) | 19/32 |
| | | 47 | 5/8 |
| Double | | Quadruple | |
| 21 | 9/32 | 49 | 21/32 |
| 23 | 5/16 | 51 | 11/16 |
| 26(a) | 11/32 | 54(a) | 23/32 |
| 28(a) | 3/8 | 56(a) | 3/4 |
| 30(a) | 13/32 | 58(a) | 25/32 |
| 33 | 7/16 | 61 | 13/16 |
| | | 63 | 27/32 |

(a) Common commercial sizes.

A common formula for the horsepower of belts is

$$hp. = \frac{P \times n \times d \times w}{130{,}000 \times K} \qquad (19)$$

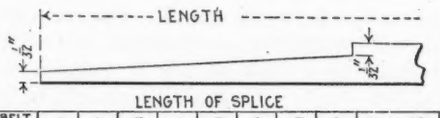
where

$P$ = effective pull per inch of width of belt.
$n$ = r.p.m. of pulley.
$d$ = diameter of smaller pulley in inches.
$w$ = width of belt in inches.
$K$ = constant depending upon arc of contact on smaller pulley.

| Arc of contact | 90° | 112.5° | 120° | 135° | 150° | 157.5° | 180° |
|---|---|---|---|---|---|---|---|
| Value of K | 2.21 | 1.72 | 1.6 | 1.4 | 1.24 | 1.17 | 1 |

The weakness of Formula (19) lies in its disregard of the value of the maximum tension, $T_1$, to which a belt is subjected. In order to use the rule and then not have the belt under a dangerously high stress, some approximation of the ratio $\frac{T_1}{T_2}$ must be had. Several writers give an average value of 2 to the ratio, where small pulleys, say 12-in. diameter, are used, and an average value of 3 where pulleys 24 in. or more in diameter are used. In all cases the two pulleys should be nearly of the same diameter. A wet belt, a very loose belt, or one that is oily will have a ratio entirely different from these values. After calculating the effective pull, $P$, the maximum tension, $T_1$, can be obtained by assigning a definite value to the ratio $\frac{L_2}{T_1}$, and the belt should be designed to safely carry the maximum tension.

Various methods of splicing leather belts are in use, such as cementing, copper rivets, rawhide lacing, wire lacing, and metallic belt hooks. When properly done, cementing gives the most satisfactory and strongest splice; in fact, the splice should be as strong as the belt itself. The laps of the splice should be beveled, as shown in an accompanying sketch (Fig. 5). The taper should be regular and is best made with a plane. Dress the belt to a feather edge, and then square the ends. Clean the laps well with gasoline before splicing. After joining, any projecting points are scraped smooth. A good cement is made by adding one pint of high-grade gasoline, 72° Bé. (poor gasoline containing kerosene will spoil the glue) to 1 gal. of melted fish or cabinet glue. Another cement is made by soaking equal weights of common glue and isinglass in water for 10 hours. Bring to a boil and add pure tannin until the mixture has the appearance of white of egg. Both cements should be applied hot, at about 212° F., or the temperature of boiling water. Place the belt over pulleys and bring the ends together by means of belt clamps. For small belts, the laps, after coating them with cement, can be pressed together between two boards lined with paper to keep the belt from sticking. For wide belts the laps are generally hammered together. Leave for three or four hours between the boards, and do not put belt under tension for at least five hours after cementing. If the belt is spliced and then run onto pulleys, as is sometimes done, undue strain is brought on the joint, and it may break. Belts should be run with the hair or dressed side next to the pulleys.




| WIDTH OF BELT IN INCHES | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 to 18 | Over 18 |
|---|---|---|---|---|---|---|---|---|---|---|
| LAP IN INCHES | 5 | 5 | 6 | 6 | 7 | 8 | 8 | 9 | Width | 18 |

FIG. 5. RATIOS USED IN BEVELING BELTS

Wire lacing, either hand or machine, makes a satisfactory joint, but this method of splicing is prohibited in some states. Rawhide lacing should be started at the middle of the belt. The two ends should be kept in line and the same tension used on both sides. The lacing should not be crossed on the pulley side. The holes should be punched in the belt. A No. 6 punch is commonly used for this work. Two rows of holes are punched, and the holes of one row are placed back of the spaces between the holes of the other row.

TABLE III. SPACING DATA FOR PUNCHING HOLES IN BELTS
(In Inches)

| Belt Width | Diameter of Hole | Size of Lace | Distance From End to First Row; Also Between Rows | Distance From Side to First Hole | Space Between Holes |
|---|---|---|---|---|---|
| 3 | 5/32 | 1/4 | 1/2 | 3/8 | 3/4 |
| 3 to 6 | 3/16 | 3/8 | 3/4 | 3/8 | 1 to 1 1/4 |
| 6 to 12 | 1/4 | 3/8 | 1 | 1/2 | 1 1/2 |
| Over 12 | 5/16 | 1/2 | 1 1/4 | 1 | 1 3/4 |

Leather belts should be cleaned and dressed every five or six months to keep them in good condition. An excellent dressing is a mixture of equal parts by weight of good fish oil (cod liver) and melted tallow. Apply to pulley side of belt, after cleaning, and wipe well with a soft cloth.

Rubber belting is made by placing together several layers or plies of duck which have been coated with rubber composition or "friction," and then running the whole through a vulcanizing press, the heat and pressure forming a solid belt. The best grade of belt is made from 32-oz. duck. Cheaper grades are made from 30-oz. and 28-oz. duck. The weight of rubber belting is about 0.045 lb. per cu.in. Standard widths range from 1 to 60 in. A 12-in. belt weighs about 1⅝ lb. per sq.ft. Standard thicknesses are from 2 to 8 plies. Thicker belts are made to order. For 30-oz. duck the thickness of belts is approximately as follows:

| Plies | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|
| Thickness of belt, in inches | 3/16 | 15/64 | 19/64 | 11/32 | 13/32 | 29/64 |

As a rough rule, belt thickness is $\frac{1}{16}$ in. per ply. A 3- or 4-ply rubber belt is equivalent to single leather belt; a 5- or 6-ply rubber belt to a double leather belt, and a 7- or 8-ply rubber belt to a triple leather belt.

A number of formulas for proportioning rubber belts are in use, and they give markedly divergent results. Only two will be stated here. They are proposed by the B. F. Goodrich Co. The first is based upon the as-

sumption that a 4-ply rubber belt 1 in. wide and traveling at a speed of 800 ft. per min. will transmit 1 hp. For a ratio of tensions of $\frac{T_1}{T_2} = 2$, the maximum tension in such a belt is 82.5 lb. Dividing by 4, the number of plies in the belt, the tension is found to be 20.6 lb. per ply. As the duck generally used in these belts has a tensile strength of from 300 to 350 lb. per ply per inch of width, the rule gives a factor of safety of from 12 to 15. In more general terms the formula becomes

$$hp. = \frac{V \times w \times p}{3200} \qquad (20)$$

where

$hp.$ = horsepower transmitted.
$V$ = speed in feet per minute.
$w$ = width of belt in inches.
$p$ = number of plies.

The second formula, shown in the form of a chart (Chart 3), indicates results that are less conservative than those found by the first formula. Belts designed by the chart will have, in general, one or two fewer plies than the number given by Formula (20). When all points are considered, the first formula gives the more economical belt for the mill man to use. To solve a problem by the chart: Begin at the left margin with the width of belt, pass horizontally to the curved line of horsepower, then either up or down to intersect the diagonal line corresponding to the desired speed, then again to the right. On the margin is the scale giving the proper number of plies. Select the next larger whole number of plies whenever a fractional number of plies is indicated.

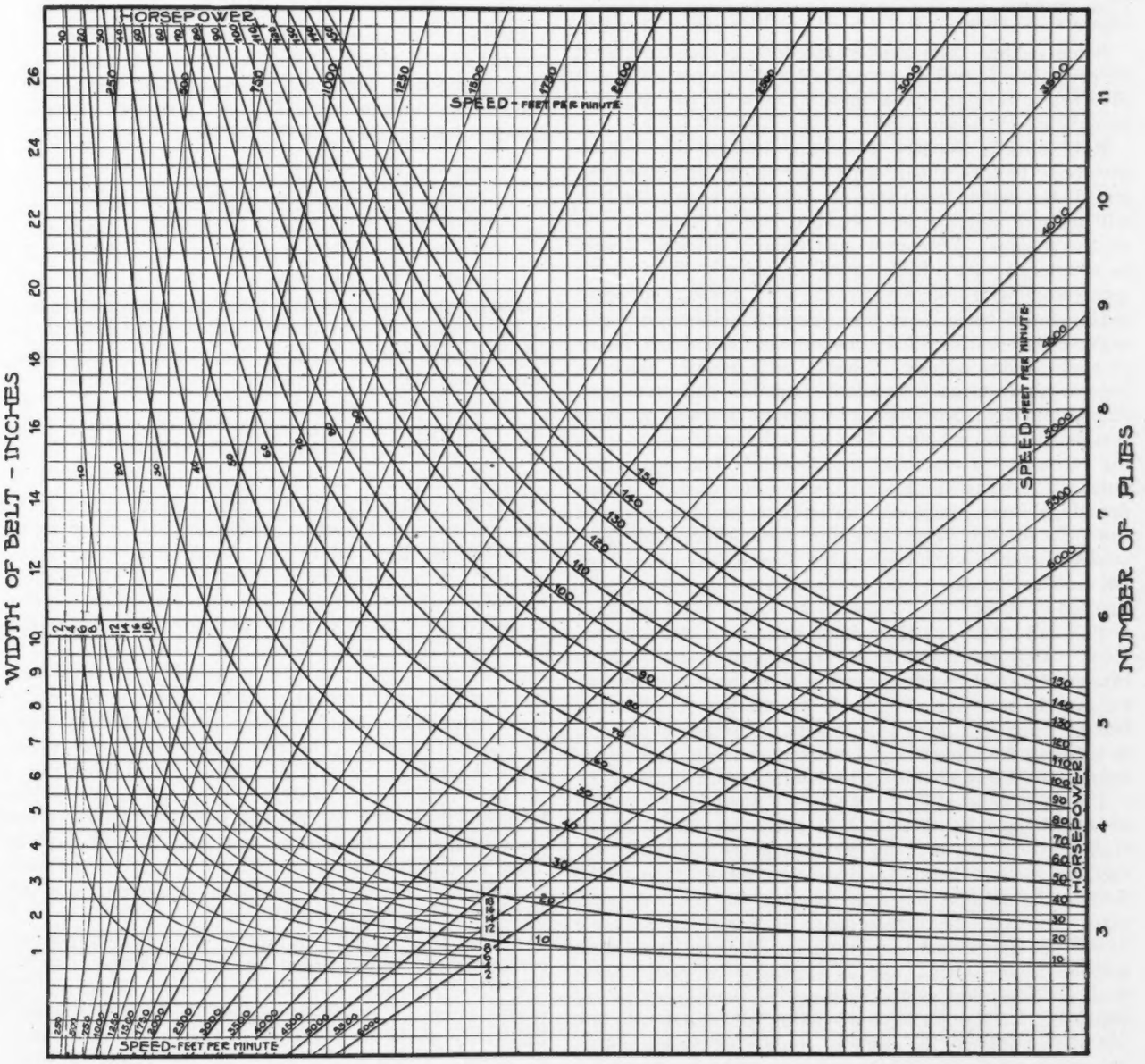



CHART 3. HORSEPOWERS, SPEEDS, WIDTHS, AND NUMBER OF PLIES OB BELTS

Rubber belting stretches less than other kinds of belting. To get the proper initial tension for a belt, shorten the exact measured length as follows:

For 3-, 4-, and 5-ply belts, shorten measured length by $\frac{5}{32}$ in. per ft. of length.

For 6-, 7-, and 8-ply belts, shorten measured length by $\frac{1}{8}$ in. per ft of length.

For 9- and 10-ply belts, shorten measured length by $\frac{3}{32}$ in. per ft. of length.

The most common method of splicing rubber belts is by means of rawhide lacing or metal belt hooks. A well-made joint should be from four to six times as strong as the working load carried by the belt. The sharp bending of a belt over small pulleys tends to separate the plies and shortens the life of the belt. A reasonable minimum diameter of pulleys for belts of different plies is given herewith.

| Plies of belt..... | 3 | 4 | 5 | 6 | 7 | 8 | 10 |
|---|---|---|---|---|---|---|---|
| Diameter in inches.. | 6 | 12 | 18 | 24 | 30 | 36 | 48 |

Some rubber belts are operated at a speed of 5000 ft. per min. However, a speed of 4000 ft. per min. will give better service, and a speed of 3000 ft. per min. insures a long life for a belt.

Rubber belts require a certain amount of filler to give body to the rubber. This filler is dry and powdery, and, if the belt is run perfectly dry, the face of the belt will become more or less polished and is likely to slip on the pulleys. Whenever this occurs, the belt should be moistened with a little boiled linseed oil. Trade catalogs recommend a dressing made of a mixture of equal parts of red lead, black lead, French yellow, and litharge, mixed with boiled linseed oil and enough japan to make it dry quickly. Should belts require cleaning before the dressing is applied, scrub the belt with soap and water only. Never use gasoline or benzene, as these liquids dissolve rubber. The use of dressings containing rosin, as one manufacturer states, "offers one of the quickest and surest routes to belt destruction." These dressings form lumps on the pulleys, keeping some of the belt surface from touching the pulley, and their stickiness tends to pull apart the plies of the belt. It is not unusual to see a belt so treated become practically a piece of hose.

The evil effects of tight belts cannot be over-emphasized. The great strain on the bearings and pulleys often causes hot boxes, burned belt surfaces, and broken pulleys, in addition to greatly increasing the friction loss of shafting. If a belt is kept in proper condition, is suitably designed for the work it is to do, and is not overloaded, there should be no trouble from slipping.

From Formula (16) it is evident that the effective pull of a belt may be increased in three ways: by direct tightening of the belt, by increasing the angle of contact, or by increasing the coefficient of friction. The first is the method generally used by the practical mill man. Its evil effects have been discussed. The angle of contact can be increased by using idler pulleys. This method is successful, and is employed in many cases with good results, as for instance in the numerous installations of the Lenix short-center belt drive. By the use of two pulleys, the angle of contact on conveyor belt drives is sometimes made as great at 360 degrees.

Statements have been made that an allowance of from 5 to 15% should be made for belt slip in calculating the power transmitted by belting. Prof. W. W. Bird[9] states that slip should be negligible in a properly designed belt, but that an allowance should be made for belt creep. This is entirely different from slip, and is due to the elasticity of the belt. The belt stretches and shortens in passing from pulley to pulley, owing to the difference in tensions, and moves or creeps on the pulleys in such a way that the driven pulley revolves somewhat more slowly than the driving pulley. The difference in peripheral speed of the pulleys varies. Under ordinary conditions the loss due to creep will not exceed 1%, and a maximum value of 2% is found only in belts that are fairly elastic and operate at a low speed. It should be noted that this loss in speed due to creep is also a loss of power, and is unavoidable as long as the material of the belt possesses elasticity.

[9]Private communication.

## Milling and Amalgamation at the Homestake

During 1918, a total of 1,628,630 tons of ore was treated at the plants of the Homestake Mining Co., of an average gold content of $3.63305 per ton. Milling and amalgamation cost $0.3141 per ton, the total amounts being distributed as follows:

| | | | |
|---|---|---|---|
| Assaying..... | $5,858.47 | Quicksilver.... | $13,990.92 |
| Coal..... | 9,304.84 | Refining..... | 5,624.40 |
| Labor..... | 203,390.18 | Silver plating | 15,021.29 |
| Lumber..... | 2,218.40 | Sundries..... | 38,896.77 |
| Machinery..... | 117,188.32 | Surveying..... | 3,770.08 |
| Oil..... | 865.72 | Teaming..... | 2,086.00 |
| Electric power.. | 62,041.99 | Water..... | 30,306.09 |
| Total..... | | | $510,563.47 |

Expenses for repairs and renewals are, doubtless, included under "Machinery," and superintendence and other general expenses under "sundries." The expenditure of $3770.08 for "surveying" is inexplicable.

## Use of the Microscope*

For some years the microscope has been the chief means of determining the exact nature of different kinds of ores and rocks. Thin sections, when viewed in polarized light, not only show the mineralogical composition of the ores or rocks but also the order of formation of the different crystals and their relations to each other. Many valuable geological deductions have been made from such information. Strange to say, the value of the application of the microscope to ore dressing has not, until recently, been generally recognized. Even in unskilled hands much can be learned by means of the instrument. The measurement of the size of mineral grains, the size of aperture and diameter of the wire in screens, the degree to which crushing must be carried in order to free the grains of valuable minerals in an ore, the amount and condition of the middling product made by any machine, and the efficiency of sulphide filming for flotation treatment are easy possibilities for the uninitiated.

With a little practice minerals of similar appearance can be differentiated, using the Becke method of finding the refractive index of grains in mineral powders. The examination of polished opaque sections in reflected light may show the presence in the ore of unsuspected minerals. Through the study of the shape of grains after an ore has been crushed the behavior of the ore under the usual conditions of concentration can be predicted with a fair degree of accuracy. A complete mineralogical analysis of the crushed ore or concentrate produced can be made by the use of the microscope combined with a separation of the grains in heavy solutions of different specific gravities.

Time spent in investigation will be well repaid by the increased efficiency of operation that will result from such a study. The advantages of this method of mill control cannot be too strongly urged.

*Excerpt, "Milling Calculations," by Robert S. Lewis, *Chemical and Metallurgical Engineering*, Mar. 1, 1919.

# Design of Small Metallurgical Mills

By HERBERT A. MEGRAW*

*The design of large and important metallurgical plants has received a maximum amount of study and care, with the object of securing the greatest economy in operation; but smaller mills are usually allowed to take care of themselves, and design has often been a consideration of decidedly secondary importance, in spite of the fact that economy is just as important in the small plant as in the larger one. There are two reasons for this unfortunate condition. First, the small mill is likely to be considered less important because its total cost, both of installation and operation, is small; and, second, because the resources of the small-mill operator are often too slender to permit the employment of capable designers. The equipment of small plants is often bought on a purely price basis, the certain result being high operation and maintenance costs and rapid deterioration.*

THE design of a small mill ought to receive just as much study and care as that of a large one. Every detail should be studied with reference to the particular ore to be treated, the local advantages and disadvantages, and the systems of metallurgy selected. If this is done, it will often be found that much of the equipment installed is superfluous; that the flow sheet can be much simplified, and that the resulting plant can be operated with much less labor than when less study is devoted to the problem. Of course, there are instances in which proper care has been given to design of the small mill, but these are so rare as to be exceptions, and they stand out as shining examples of efficiency.

## Duplication of Existing Practice Often Undesirable

Too often the small mill is built to follow a system of ore treatment that has proved successful at some other plant, without due regard to the peculiarities of the ore to be handled. It is so seldom that one ore can be treated in exactly the same manner employed in the treatment of a different one that such a course should never be followed without the most careful consideration. Not only should previous practice be regarded as not necessarily a course to be followed, but each step in any proposed process should be carefully studied with the view of improving upon it, even where the change or improvement means the breaking of an absolutely new trail.

Nobody with ripe experience and sane judgment should hesitate to do something that has not been done before. Of course, experience and judgment are necessary to justify a step that involves a radical departure from established practice, and the advantages and disadvantages ought to be considered from all points of view, metallurgical and mechanical, so that no violations of chemical or physical laws shall be attempted. Every possible simplification should be incorporated in plant design, with the idea of economizing on labor.

Labor costs have reached a point at which they may easily determine the success or failure of a metallurgical enterprise, which, of course, is nothing more than a commercial venture. There is little hope for a lowering of labor costs in the near future, and it is therefore imperative to reduce the labor requirements to the lowest possible point. This applies not only to plant operation, but also to the durability of the equipment employed. Repairs consist largely of labor, whether at the plant or at the factory, so that well-designed and well-constructed machinery will much more than earn its slight additional cost. This applies to every kind of machine and device entering into the equipment of a mill, and should be so considered. Consequently, it will apply to all equipment for any purpose mentioned in this paper, without further specific attention being drawn to that feature.

## Rock Breaking in Small Mills

To consider the equipment of a small metallurgical plant in logical sequence, one must begin with the primary rock breaker. All mills require this equipment, but most of the smaller plants purchase almost any breaker that is offered at a low price. The result is excessive power consumption, low capacity, because of faulty design, and high maintenance cost, due to the poor material which must inevitably be used in a cheap machine.

There are, basically, just two types of machine that can be used for rock breaking. One is the Blake or Dodge or jaw type; the other is the gyratory. Both are well known. There are many variations of each, usually known under trade names, but they all depend, basically, upon the principles of one or the other. Each of these has its field. Each is useful where the other cannot economically be employed, but some care is required to select the one most serviceable for the work at hand. To use one where the other is indicated would be a mistake that would lead to excessive cost and low efficiency. Consequently, the factors that lead to the selection of either of the types should receive careful consideration.

The jaw crusher, as is well known, performs its work by compressing and breaking rock between a stationary wall and a moving jaw. In the Dodge type the moving jaw is pivoted at the bottom and has its maximum movement at the top. This gives a constant-discharge opening, with uniform product and small capacity. In the Blake type, the pivot is at the top, or opening, and maximum movement at the bottom, or discharge point. Consequently, the capacity is comparatively large and the product by no means uniform. Another feature of importance is the angle of nip. In the Dodge type of breaker this angle decreases as compression is applied, thus increasing the efficiency. In the Blake type, the angle increases with compression, having a tendency to push the rock out of the machine, and consequently decreasing its efficiency. Dodge-type breakers are rarely used, the larger capacity of machines of the Blake type making them preferred, with or without real reason.

The gyratory crusher breaks rock by the gyrations of a conical crushing head against a stationary wall, forming the outside of an inverted cone. The conical crushing head is fixed on a vertical shaft which has

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its fixed point at the top and its point of greatest movement at the bottom. The length of the shaft is sufficient to provide a proper leverage for performing the work of rock breaking. The gyratory movement is attained by placing the lower end of the vertical shaft in an eccentric bearing. With this type of machine, the eccentricity is not great; consequently, the angle of nip is practically constant, and the discharged product is much more uniform than with the Blake-type breaker. As the breaker opening is circular, crushing is continuous, not intermittent, and beam action comes into play, preventing the discharge of wide, flat slabs of rock, such as are constantly discharged through the rectangular opening of a jaw crusher. The product of a gyratory is much more uniform and more cubiform than that of either type of jaw crushers.

Gyratory rock breakers require no more head-room than machines of equivalent output of the jaw type. The vertical shaft must be long enough to provide a crushing head of proper length and to allow for proper leverage, below the head, to apply pressure upon the rock. Disregard of the latter feature, in an effort to lessen the head-room requirements of gyratory breaking machines, has led to the designing of breakers with short shafts, where the power for crushing is applied almost directly to the bearing of the eccentric. Any rock crusher, whether jaw or gyratory, which takes the crushing pressure directly upon a bearing is mechanically wrong and has not taken advantage of the features inherent to the type of the machine.

### Selection of Primary Crushing Machine

The selection of a suitable primary crushing machine is important, and its type must depend upon the character of work to be done. The gyratory machine has greater capacity for its weight and power consumption than either of the jaw types. This superiority reaches its maximum with some of the large machines. The accompanying table shows a comparison of some standard sizes of Blake-jaw and gyratory machines having the same opening width.

The selection of a primary crusher, however, will not depend altogether upon the efficiency of the machine, but rather upon the width of opening of the crusher, because, to avoid the expense of sledging, the crusher opening should be large enough to take the largest piece of rock coming from the mine. If the pieces of rock are large, 10 to 13 in., or more, a jaw crusher would be indicated, because a gyratory large enough to take these pieces would have greatly excessive capacity, would be much heavier, consequently costing more, and would require much greater power. In plants where the full capacity of the gyratory can be used, it is a much more economical machine, but in the small mill it is necessary to employ a Blake-jaw breaker for primary reduction.

Following the primary breaker a screening device should be used to remove the material of fineness below that of the product of the secondary crusher. A grizzly is often employed for this service, but is not as effective as a revolving screen, or trommel, and requires continuous attendance. The automatic machine is much cheaper in the long run. It should be used to minimize the work of the secondary crusher.

For the secondary crusher there is no question as to the utility of the gyratory type. The rock has been reduced in size so as to be appropriate for a high-speed gyratory with small opening. This machine can be so selected as to make use of its maximum capacity, keeping it at work continuously. Its product should be appropriate for the succeeding reduction equipment. The great advantage of this step in reduction lies in its ability to deliver a fine product appropriate for, say, ball-tube mill finishing, and doing it at crusher cost, rather than at tube-mill cost. This is economy, because a smaller tube mill, with lower installation and operation cost, will suffice. Ball-tube mill feed should be at least 1-in. cube in size for best results, and if it is delivered at ½-in. size the tube mill will have less work to do and will do it with greater economy. This is a point at which careful study will be repaid in low maintenance costs. Though large-diameter tube mills of great length often have to be used, and may be the most economical equipment for plants of great capacity, they had better be avoided in the small plant, on account of their great cost and large power requirements. In the small plant the desideratum should be to do as much breaking as possible in rock-breaking machines and at rock-breaking cost. Let the fine-grinding machine do as little of this work as can be arranged.

COMPARISON BETWEEN GYRATORY AND JAW CRUSHERS

| | Gyratory | Jaw | Gyratory | Jaw | Gyratory | Jaw |
|---|---|---|---|---|---|---|
| Crusher opening, in. | 7x52 | 7x10 | 15x112 | 15x30 | 30x230 | 30x48 |
| Size of product, in. | 2½ | 2½ | 2½ | 4 | 5 | 6 |
| Weight of crusher, lb. | 10,000 | 6,000 | 70,000 | 39,000 | 225,000 | 80,000 |
| Capacity, tons per hour | 15 | 8 | 100 | 48 | 750 | 95 |
| Horsepower | 10 | 7 | 53 | 30 | 150 | 1.10 |
| Capacity, tons ÷ weight tons. | 3 | 2.66 | 2.86 | 2.5 | 6.7 | 2.37 |
| Capacity, tons ÷ horsepower. | 1.5 | 1.14 | 1.89 | 1.6 | 5 | 0.863 |

### Ball-Tube Mill Is Customary Finishing Machine

Placing the burden of work as far as can be done upon the rock-breaking machines allows a smaller installation of finishing equipment. Usually the finishing device is the ball-tube mill. Rolls, Chilean mills, and other machines are employed, but as the ball-tube mill is by far the most popular, only this will be considered in this discussion. There is good reason for the preference shown for the tube mill. It is a simple device, does not require frequent attention, and can be so adjusted as to deliver a product of almost any maximum fineness. The rate of feed governs the fineness of the discharge, so that heavy feeding provides a coarse discharge, whereas light feeding produces finely ground products. If a very finely ground product be desired, it is usual to use a tube of comparatively great length; a short tube is employed to deliver a coarse discharge. In general, it is best to use the shortest possible tube consistent with proper product, thus reducing the power requirements. A ball-tube mill requires approximately 10 hp. per ton of ball charge to move it, and as the short mill carries fewer balls, a large power saving is effected.

That the discharge from the ball mills may contain the smallest possible amount of material greater in size than desired, the product is usually classified and the oversize returned to the mill for further grinding. Thus, for a coarsely granular product, say between 20 and 60 mesh, it is good practice to use a short mill, 5 or 6 ft. long, and return the oversize. The diameter of the mill depends on the size of the feed to it. For large rock 1½- to 2½-in. cube, mills up to 8-ft. diameter are employed. For material ½- to 1-in. cube, the diameter need not be more than 5 ft. Here, again, the value of the secondary crushing machinery is demonstrated, because a great deal of power and installation cost is saved by feeding fine rock to a smaller ball-tube mill.

The classification of the product of the ball-tube mill is usually performed in hydraulic classifiers, although screens have been used. This point should be the subject of particularly careful study. Screen classification has much in its favor, the principal objection having been the high maintenance cost of the screening machines used. If mechanical devices are available for economically screen-classifying the ball-mill product, a good deal of extra work, and consequently expense, will be avoided. Here is a chance for the small-mill designer, as well as for the designer of the larger mill, to take a progressive step in wet metallurgy.

The design of any mill will, of course, depend upon the system of metallurgy to be used. In the accompanying flow sheets, No. 1 shows the outline of a simple all-sliming cyanide plant, and No. 2 shows a concentrating

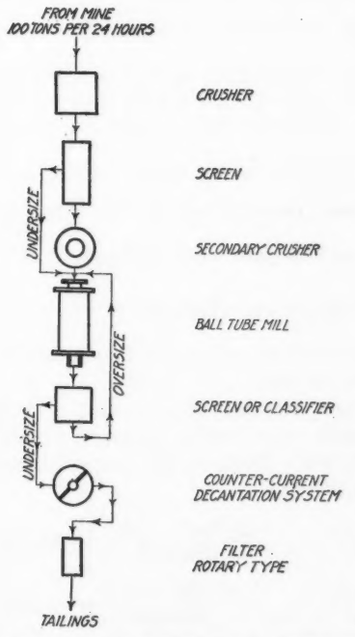


FIG. 1. A 100-TON ALL SLIMING CYANIDE PLANT

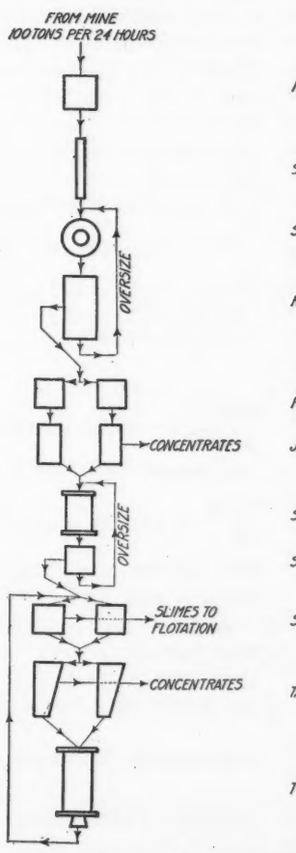


FIG. 2. A 100-TON CONCENTRATION PLANT

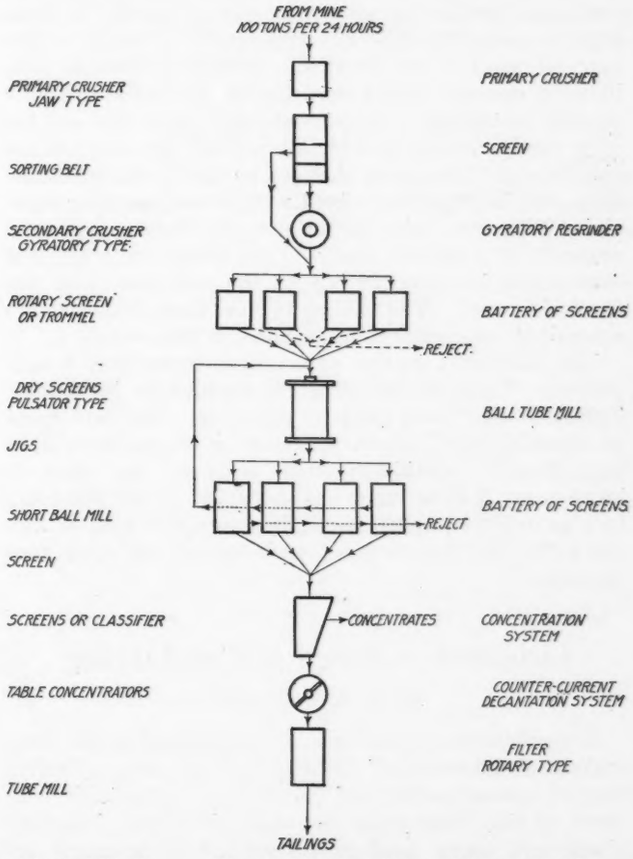


FIG. 3. A 100-TON CYANIDE PLANT —SCREEN-REJECTION SYSTEM

plant with equipment for ore sorting, jigging, table concentration, and flotation. The liberal equipment of screens provides definite particle-size classification and insures the right class for each recovery system. The argument as to when and where any particular device should be used is never-ending, but the outlines here shown may give suggestions to any one having problems of the kind under consideration. No particular type of ore has been considered in their connection. Probably other combinations would be better under some circumstances, but the actual equipment is about what would be required for simple design and construction.

In the design of a metallurgical mill on any scale the crushing and grinding section should receive much more study than is usually accorded to it. The processes of metal recovery—cyanidation, amalgamation, concentration, or flotation—usually get their share of attention, as these details are the subject of more spectacular discussion, but too often the crushing and grinding are merely stereotyped practices following something that has already been done. Nevertheless it is true that successful plants depend quite as much on logical ore-reduction systems as they do on metallurgical processes. An ore may not be ground fine enough, or it may be ground too fine. Or certain parts of it may require separate treatment of a type entirely different from that given to the remainder. The subject requires careful attention if the best, most appropriate, and most economical system of treatment is to be incorporated in the completed plant.

Stage crushing and grinding comprise, I believe, the method embodying the greatest ultimate advantage. Of course I am aware of the fact that this is not invariably true, as there are some ores so formed, either by wide and uniform distribution of metal, or otherwise, that their efficient treatment requires all of the rock to be reduced to a uniformly fine product. In such circumstances stage reduction may be limited to two or three steps. When the metal or mineral is not uniformly disseminated, however, it will often be found better to use perhaps a large number of steps, separating at each step the material already fine enough for treatment. This tends to minimize the subsequent installation, reducing its work in proportion to the product removed from the mill feed before reaching it. A typical example of treatment of this sort is the bypassing of fines around the primary crushing machines by means of a grizzly. This is common practice, but it might well be carried much further. In metallurgy, the jigging of granular material, table

treatment of sand, and flotation of slimes all have for their object the same purpose. Flow sheet No. 2 is an example.

### Screening Out Barren Material From the Mill Pulp

It is conceivably possible to take still another step in the search for an efficient treatment method. Most mill operators will admit that in their crushing and grinding stages there is usually a point where a barren or nearly barren product might be separated from the mill flow, either by hydraulic means or by screens. This is particularly true in ores in which the valuable mineral is more or less concentrated in spots or localities in the rock, or where the mineral and rock break to widely different finenesses. Under such conditions, screen separation may take out an economically unprofitable portion or a portion better suited to some other form of treatment. Apparently it would be the part of wisdom to do this. Screening devices cost little to operate, and economize on grinding and subsequent metallurgical treatment—processes that are far more costly. It has been clearly proved that any ore not able to stand treatment changes by itself will not stand them any better when mixed with more valuable material. Why not take advantage of this fact in mill design? If a portion that will not stand the treatment charge can be screened out of the mill run, why not throw it away? The outline in flow sheet No. 3 shows a possible arrangement to accomplish this result.

The discussion in this paper is no more than a suggestion. Each problem must be decided on its merits. The same diet is not good for everyone. The care spent in planning for highest economy in operation will be magnificently repaid, in small mills no less than in large ones. It is better to spend $10,000 or $20,000 more in a properly equipped plant than to spend 10c. or 20c. more for the treatment of each ton of ore that goes through it.

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## Driers as Applied to Ore Drying

By L. R. Christie*

The ultimate exhaustion of commercial-grade ores makes consideration of the simplest and most effective way of concentrating and increasing the metallic contents of the lower-grade deposits advisable. Washing plants are being used extensively, but, in many instances, the removal by drying of part of the moisture contained in the mined ore is sufficient to avoid penalties, frequently premiums may be gained, and the plant is simpler and less expensive. Drying after washing can sometimes be practiced to advantage.

Furnace operators generally object to very dry ore, on account of the dust losses from the furnace; but when about 8% moisture is left this objection is overcome, and, as the ore generally contains about 18% moisture when mined, there is room for considerable increase in grade. To illustrate: Assuming ore to contain 56% iron when dried, the iron content when this ore contains 18% moisture would be

$$\frac{56 \times 82}{100} = 45.92\%$$

and when containing 8% would be $\frac{56 \times 92}{100} = 51.52\%$.

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The weight of dried ore per ton of 8% material would be

$$2240 \times 92 = 2060.8$$

and the original wet weight $\frac{2060.8}{82\%} = 2513.17$.

The loss of weight being

$$2513.17 - 2240 = 273.17$$

and the weight of water originally contained

$$2513.17 - 2060.8 = 452.37$$

There would then be an increase in metallic ore from 45.92 to 51.52% and a reduction in shipping weight per ton dried ore of $\frac{273.17}{2240} = 12.2\%$.

By these methods the increase in value of ore and saving in freight may be determined for any material, and a gain would be shown almost invariably if proper attention is paid to the efficiency of the drier and ruggedness of construction. Definite laws govern any process of heat transfer. Driers are manufactured to apply these laws to best advantage and utilize over 85% of the heat generated in the furnace. In drying one ton of ore at 8% moisture from an original moisture of 18%, the following heat balances must be considered:

Temperature of ore and moisture on entering the drier, 62° F.

| | | |
|---|---|---|
| $2060.8 \times (212 - 62) \times .2$ | = | 61,824 B.t.u. to heat solids 212° |
| $452.37 \times (212 - 62)$ | = | 67,855 B.t.u. to heat water 212° |
| $273.17 \times (970.4)$ | = | 265,084 B.t.u. to evaporate water |
| | | 394,763 total B.t.u. required |

$\frac{394,763}{13,500} = 29.24$ lb. of coal (containing 13,500 B.t.u. to the pound) required if all the heat were utilized.

$\frac{29.24}{85\%} = 34.4$ lb. of coal burned per dried ton of ore when 85% efficiency is obtained (15% being lost in radiation, exhaust gas, and carbon in ash).

A plant of 300,000 tons' capacity per annum (1000 tons per 24 hours) would cost, under present conditions, approximately $35,000. The cost per ton of dried ore would then be as follows:

| | | |
|---|---|---|
| Depreciation and repairs: | $\frac{\$35,000 \times 12\%}{300,000}$ | = $0.014 |
| Interest on investment: | $\frac{35,000 \times 6\%}{300,000}$ | = .007 |
| Fuel at $6 per ton: | $\frac{34.4 \times 6}{2000}$ | = .103 |
| 100 hp. at 2½c. per kw. hour 42 tons per hour | $\frac{100 \times .746 \times .025}{42}$ | = .044 |
| Labor: 2 men per shift, or 6 per 24-hour day at $4.00 per day | $\frac{4 \times 6}{1000}$ | = .024 |
| Total cost per dried ton . . . . . | | $0.192 |

If driers of 50% efficiency were used, which is frequently the practice, the fuel consumption per ton of dried ore would be 58.5 lb. of coal, making the cost of drying per ton $0.206, an increase of 10.3c. or $30,900 per year.

To obtain high efficiency, the greatest difference possible should be maintained between the initial and exhaust temperatures, as these differences represent the percentage of heat given up in the apparatus. A temperature of 120° F. is as low as has been found practicable to reduce exhaust, but initial temperature is de-

pendent more on the drier design. If the drier plates are not properly protected by wet material, or the surfaces are not sufficiently large to diffuse the heat, and the hot gases pass over same at high velocity, due to confined area, the initial temperature must be kept down by using excess air, and this involves the double objection of increasing the volume of waste gases, carrying away a proportionate amount of heat, and necessitating increased velocity through the drying compartment, taking out more dust, which is often the most valuable part of the product.

No attempt should be made to take sufficient air through the material to absorb the moisture, as this increases the volume, with the objection cited above. In practice I have obtained the best results when the volume of gas used was not more than sufficient to absorb 50% of the moisture, the remainder going off as a free vapor. This is not a fixed quantity, but is controlled by the amount of moisture before and after drying and the material treated.

In drying ore or material of a sticky tendency, it is necessary that the drier shell be externally heated at the feed end, as this causes a film of steam to form between the plates and material, preventing adhesion. It is hardly necessary to mention the importance of rugged construction and accessibility to working parts to prevent delay and expense for repairs. The initial cost of a drier installation is not as serious a consideration as efficiency and continuity of operation.

## Homestake Mining Expenses

The expenses for mining various properties of the Homestake Mining Co. during 1918 were as follows:

| | | | |
|---|---|---|---|
| Assaying | $8,113.37 | Powder storage | $4,084.66 |
| Damages | 216.08 | Sundries | 79,012.83 |
| Coal | 89,166.77 | Surveying | 15,969.05 |
| Labor | 1,502,505.34 | Teaming | 4,205.00 |
| Lumber | 6,134.83 | Diamond drilling | 13,083.33 |
| Machinery | 340,854.80 | Timbers | 62,877.87 |
| Oil | 10,929.95 | Transportation | 14,402.82 |
| Electric power | 25,573.54 | Water | 204.87 |
| Steam | 76,098.10 | Wood | 755.00 |
| Powder | 224,377.69 | | |
| Total | | | $2,478,565.90 |

"Transportation" probably includes ore tramming. A total of $216.08 occurs in a separate account of "Damages," but whether these are of the material or legal variety is not stated. The expenditure of $204.87 for "water" probably refers to the cost of drinking water. The value of such separate accounts, even when logically classified, is dubious when the sum of $79,012.83 appears under "sundries."

## Specific Gravity Table

In the accompanying table, the specific gravities of the commoner minerals and metals have been classified and arranged in sequence. The table will be found useful for the rough differentiation of concentrated or raw products, and as a reminder of the various forms in which a metal may occur. The figures for specific gravity are from Dana.

| Sp.Gr. | Gold | Silver | Copper | Lead | Zinc | Miscellaneous | Gangue |
|---|---|---|---|---|---|---|---|
| | | | | | | Bitum. Coal 1.14–1.4 | |
| | | | | | | Anthracite 1.32–1.7 | |
| 2 | | | Chrysocolla 2–2.24 | | | Graphite 2.09–2.23 | Opal 1.9 –2.3 |
| | | | | | | | Gypsum 2.31–2.33 |
| | | | | | | Brucite 2.38–2.4 | Orthoclase 2.47–2.52 |
| | | Quartz line 2.66 | | | | Serpentine 2.5 –2.65 | Kaolinite 2.6 –2.63 |
| | | | | | | Labradonite 2.7–2.72 | Quartz 2.65–2.67 |
| | | | | | | | Calcite 2.71 |
| | | | | | | Muscovite 2.76–3 | Anorthite 2.74–2.76 |
| 3 | | | | | | | Talc 2.7 –2.8 |
| | | | | | | Anhydrite 2.9–2.98 | Dolomite 2.8 –2.9 |
| | | | | | | Tourmaline 2.98–3.2 | Aragonite 2.93–2.95 |
| | | | | | | | Biotite 2.7 –3.1 |
| | | | | | | Magnesite 3.0 –3.12 | Fluorite 3.01–3.25 |
| | | | | | | Apatite 3.17–3.23 | Amphibole 2.9 –3.4 |
| | | | | | Calamine 3.4 –3.5 | Orpiment 3.4 –3.5 | Pyroxene 3.2 –3.6 |
| | | | | | | Realgar 3.55 | Epidote 3.25–3.5 |
| | | | | | | Titanite 3.4 –3.56 | |
| | | | | | | Diamond 3.52–3.53 | |
| | | | | | | Cyanite 3.56–3.67 | Rhodonite 3.4 –3.68 |
| | | | | | | Spinel 3.5 –4.1 | Rhodochrosite 3.45–3.68 |
| | | | Azurite 3.77–3.83 | | | Limonite 3.6 –4.0 | |
| | | | | | | Siderite 3.83–3.88 | |
| | | | Malachite 3.9 –4.03 | | *Sphalerite 3.9 –4.1 | Corundum 3.95–4.1 | Garnet 3.15–4.3 |
| | | | | | Willemite 3.89–4.18 | Manganite 4.2 | |
| | | | | | | Rutile 4.18–4.25 | |
| | | | *Chalcopyrite 4.1–4.3 | | Smithsonite 4.3 –4.45 | Psilomelane 3.7–4.7 | |
| | | | *Enargite 4.43–4.45 | | | Chromite 4.32–4.57 | Barite 4.3 –4.6 |
| | | | | | | *Stibnite 4.52–4.62 | |
| | | | | | | *Pyrrhotite 4.58–4.64 | |
| | | | | | | Ilmenite 4.5 –5.0 | |
| | | | | | | Zircon 4.68–4.7 | |
| | va | | | | | *Molybdenite 4.7–4.8 | |
| | | | *Tetrahedrite 4.4 –5.1 | | | Pyrolusite 4.82 | |
| | | | | | | Marcasite 4.85–4.9 | |
| 5 | Pyrite line 5 | | | | | *Pyrite 4.95–5.1 | |
| | | | | | Franklinite 5.07–5.22 | | |
| | | | *Bornite 4.9 –5.4 | | | Hematite 4.9 –5.3 | |
| | | | *Chalcocite 5.5 –5.8 | | | Magnetite 5.17–5.18 | |
| | | | *Bournonite 5.7 –5.9 | | Zincite 5.43–5.7 | Millerite 5.3 –5.65 | |
| | | Cerargyrite 5.55 | | | | Arsenopyrite 5.9–6.2 | |
| | | Iodyrite 5.6–5.7 | | | | | |
| 6 | | *Proustite 5.77–5.64 | | Anglesite 6.12–6.39 | | Scheelite 5.9 –6.1 | |
| | | *Pyrargyrite 5.77–5.86 | Cuprite 5.85–6.5 | | | | |
| | | *Polybasite 6 –6.2 | | | | | |
| | | *Stephanite 6.2 –6.3 | | | | *Bismuthenite 6.4–6.5 | |
| 7 | | | | Cerussite 6.46–6.57 | | | |
| | | | | Pyromorphite 6.5 –7.1 | | | |
| | | *Argentite 7.2 –7.3 | | Wulfenite 6.7 –7.0 | | Wolframite 7.2 –7.5 | |
| | | | | *Galena 7.4 –7.6 | | | |
| 8 | *Sylvanite 7.9 –8.3 | | | | | | |
| | | *Hessite 8.31–8.45 | | | | *Cinnabar 8 –8.2 | |
| 9 | | | Copper 8.8 –8.9 | | | | |
| 10 | | Silver 10.1 –11.1 | | | | | |
| 13 | | | | | | Mercury 13.5 | |
| 14 | Amalgam 13.75–14.1 | | | | | Platinum 14 –19 | |
| | Gold-Electrum 15.6 –19.3 | | | | | | |
| 20 | | | | | | Iridosmine 19.3–21.1 | |
| 22 | | | | | | Iridium 22.4 | |

* Minerals that yield to flotation.

COMPARATIVE SPECIFIC GRAVITIES OF MINERALS

# Economics of Concentration

BY R. S. HANDY*

*A discussion of the recent paper of A. P. Watt which appeared in the "Journal" of May 3 and which was entitled "Economics of Concentration." In his paper Mr. Watt showed that, in addition to technical efficiency and metallurgical recovery, it is important for the metallurgist to consider carefully the further treatment of low-grade concentrate, particularly the concentrate which cannot be profitably marketed. He suggested the desirability of re-treatment after a full consideration of smelter charges and freight rates. The use of a separate re-treatment plant was advocated where the low-grade concentrate is of such a nature as to admit of cleaning. In the paper that follows, R. S. Handy defines the conditions under which it is profitable to ship a concentrate and takes the position that a re-treatment plant separate from the mill fosters carelessness on the part of mill men and operatives.*

I HAVE read with great interest A. P. Watt's article entitled "Economics of Concentration," in the *Journal* of May 3, in which he makes a strong argument for the use of "economic recovery" in determining mill efficiency. This factor of economic recovery, or "economic extraction," as it is called, has been the guilding element in the operation of the Bunker Hill & Sullivan concentrators for the last nine years, having

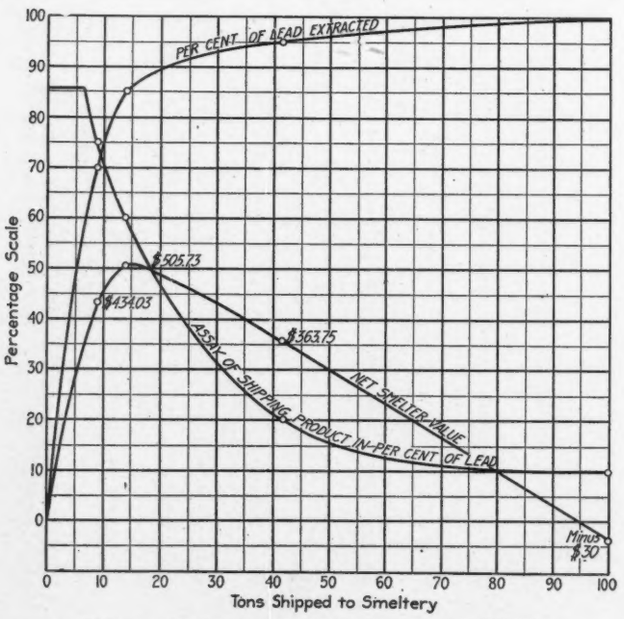


FIG. 1. MAXIMUM ECONOMIC EFFICIENCY

been introduced by myself in 1910. For many years, while the mill efficiency was being gradually built up by changes in the flow sheet, the economic extraction appeared upon each daily report as well as in the monthly and yearly reports, as it still does.

Because the subject is one of much importance, and in the hope of provoking further comment from lead operators, I desire to discuss some of the points brought out in Mr. Watt's article.

The use of "profit" and "loss" in his discussion of "smelter returns" is, I think, unfortunate, because it might leave the impression that it is profitable to ship any grade of concentrate that will return any net value whatever. To my mind it is profitable to ship a concentrate only when the gain due to eliminating waste therefrom is equaled by the value of the metal lost, plus the cost involved in eliminating this waste. I shall try to illustrate this point by examples.

## COMPARISON OF POSSIBILITIES

Suppose 100 tons of mill feed assays 10% lead and contains 10 tons of lead in the form of galena. Assuming a price of 4c per lb. for lead, the total value of the lead in this lot is $800. Taking a smelter contract in which 90% of the lead is paid for at market rates, and under the terms of which $7.50 per ton is deducted for freight and treatment, various methods of handling this lot of ore may be compared.

*Example 1*—If the ore is shipped directly to the smeltery, the metallurgical extraction, so far as the mill is concerned, is 100% and the smelter returns are:

| | |
|---|---|
| 90% of 10 tons equals 9 tons lead at $80 | $720.00 |
| Freight and treatment on 10.44 tons galena at $7.50 | 78.30 |
| Net value of galena | $641.70 |
| Freight and treatment on 89.56 tons waste at $7.50 | 671.70 |
| Net smelter value (deficit) | $30.00 |

*Example 2*—Suppose, instead, the ore is concentrated and the extraction is 95% of the lead in a concentrate assaying 20% lead. There will be 47.5 tons of such concentrate, and the smelter returns will be:

| | |
|---|---|
| 90% of 9.5 equals 8.55 tons lead at $80 | $684.00 |
| Feight and treatment on 9.94 tons galena at $7.50 | 74.55 |
| Net value of galena | $609.45 |
| Freight and treatment on 37.56 tons waste at $7.50 | 281.70 |
| Net smelter value | $327.75 |
| Economic extraction { Gross value lead / Net amelter value } 40.97% | |
| Cost of milling 100 tons ore at 40c | 40.00 |
| Profit | $287.75 |

In this example there has been eliminated 52.0 tons of waste at a saving of $390 in freight and treatment at a cost of $71.65 in lead lost plus milling cost, leaving a gain, due to these causes, of $318.35.

*Example 3*—Assuming an extraction of 85% of the lead in a concentrate assaying 60% lead, there will be 14.17 tons of such concentrate, upon which the smelter returns will be:

| | | |
|---|---|---|
| 90% of 8.5 tons equals 7.65 tons lead at $80 | | $612.00 |
| Freight and treatment on 8.90 tons galena at $7.50 | | 66.75 |
| Net value of galena | | $545.25 |
| Freight and treatment on 5.27 tons waste at $7.50 | | 39.52 |
| Net smelter return | | $505.73 |
| Economic extraction, 63.22% | | |
| Cost of milling 100 tons at 60c | | 60.00 |
| Profit | | $445.73 |
| Saving due to waste | $632.17 | |
| Costs in lead and milling | 154.88 | |
| Gain | $477.29 | |

*Example 4*—Again, if there is a metallurgical extraction of 70% and a grade of 75% lead, 9.33 tons of concentrate are produced, as is shown:

*Mill superintendent, Bunker Hill & Sullivan Mining and Concentrating Co., Kellogg, Idaho.

| | |
|---|---|
| 90% of $7 equals 6.3 tons lead at $80. | $504.00 |
| Freight and treatment on 8.14 tons galena at $7.50. | 61.05 |
| Net value of galena. | $442.95 |
| Freight and treatment on 1.19 tons waste at $7.50. | 8.92 |
| Net smelter return. | $434.03 |
| Economic extraction equals 54.25% | |
| Cost of milling 100 tons at 80c. | 80.00 |
| Profit. | $354.03 |

Here $662.77 has been saved in eliminating 88.37 tons of waste, but the lead lost was worth $189.90 and the milling cost $80, leaving a gain of only $392.87. It is obvious that the economic peak occurs somewhere near the conditions expressed in *Example 3*. The relation of the metallurgical extraction to the concentrate assay will affect this economic peak, but there is a maximum economic efficiency for every concentrating plant. With a given smelter contract the economic peak is not affected by ordinary variations in metal prices. The conditions just described are shown graphically in Fig. 1.

Though smelter contracts and metal prices have a bearing upon profit from ore concentration, waste is valueless, and under the conditions outlined at the beginning, it costs as much (from the producer's point of view) to ship and to smelt a ton of waste as it does to ship and to smelt a ton of galena. This is a vital matter in lead concentration, but, as Mr. Watt says, it receives too little attention.

This brings up the question of re-treating, or re-grading, products from a concentrator by means of a special plant built for the purpose. I am opposed to this procedure unless the products from re-treatment are covered by a special smelter contract. There should be no machine in a re-treatment plant superior for concentrating purposes to the machines in the concentrator,

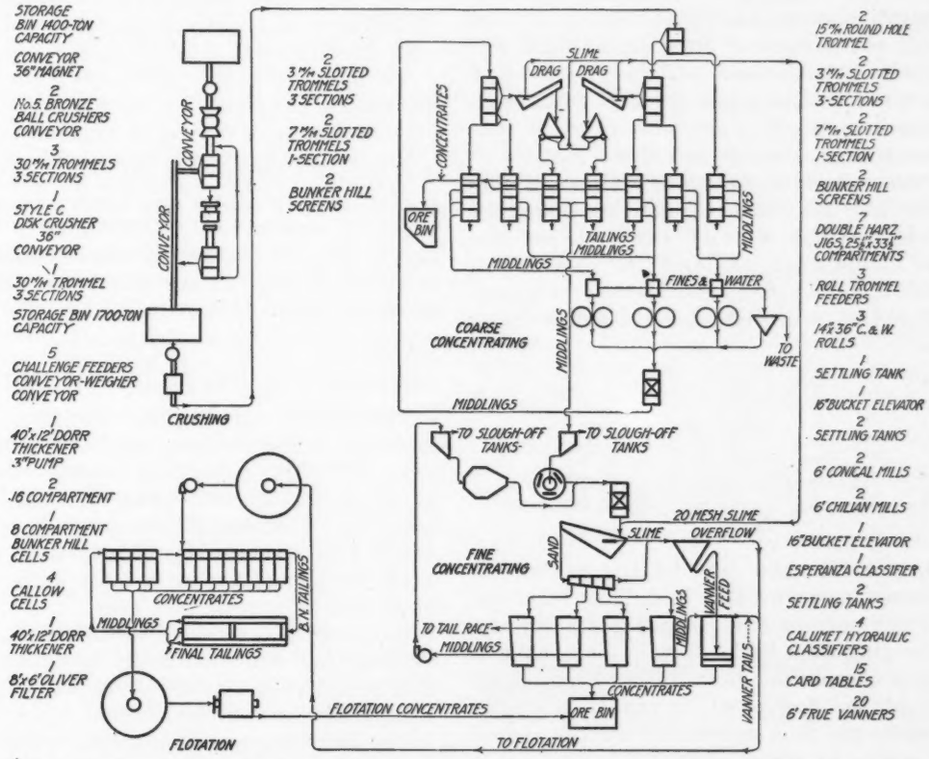


FIG. 2. FLOW SHEET BUNKER HILL & SULLIVAN M. AND C. CO.'S WEST MILL, NO. 2

*Example 3*. The relation of the metallurgical extraction to the concentrate assay will affect this economic peak, but there is a maximum economic efficiency for every concentrating plant. With a given smelter contract the economic peak is not affected by ordinary variations in metal prices. The conditions just described are shown graphically in Fig. 1.

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TABLE I.

| Size | First Class Per Cent. Weight | First Class Assay, Per Cent. Pb | Second Class Per Cent. Weight | Second Class Assay, Per Cent. Pb | Middling Per Cent. Weight | Middling Assay, Per Cent. Pb | Tailing Per Cent. Weight | Tailing Assay, Per Cent. Pb | Total Per Cent. Weight | Total Assay, Per Cent. Pb |
|---|---|---|---|---|---|---|---|---|---|---|
| 30 mm. to 15 mm. | 0.45 | 80.0 | 2.66 | 45.0 | 19.70 | 23.3 | 21.82 | 0.0 | 44.63 | 13.7 |
| 15 mm. to 7 mm. | 1.60 | 75.0 | 2.93 | 40.0 | 20.55 | 8.6 | 21.58 | 0.0 | 46.66 | 8.8 |
| 7 mm. to 3 mm. | 0.42 | 70.0 | 0.57 | 30.2 | 4.38 | 1.9 | 3.30 | 0.0 | 8.67 | 6.2 |
| Totals | 2.47 | 75.0 | 6.16 | 41.0 | 44.63 | 14.4 | 46.70 | 0.0 | 99.96 | 10.8 |

TABLE II.

| Product | Broken to Pass 15 mm. First Class Per Cent. Weight | Broken to Pass 15 mm. First Class Per Cent. Pb | Broken to Pass 15 mm. Second Class Per Cent. Weight | Broken to Pass 15 mm. Second Class Per Cent. Pb | Broken to Pass 7 mm First Class Per Cent. Weight | Broken to Pass 7 mm First Class Per Cent. Pb | Broken to Pass 7 mm Second Class Per Cent. Weight | Broken to Pass 7 mm Second Class Per Cent. Pb |
|---|---|---|---|---|---|---|---|---|
| 30 mm., 2d class. | 0.94 | 68.0 | 1.72 | 33.0 | 0.14 | 65.0 | 1.58 | 30.0 |
| 15 mm., 2d class. | .... | .... | .... | .... | 0.42 | 60.0 | 2.51 | 37.0 |
| Totals. | 0.94 | 68.0 | .... | .... | 0.56 | 60.7 | 4.09 | 34.0 |

In connection with the selection of concentrates of a desired grade, a recent test on Bunker Hill mill feed may be of interest. The feed, being all through 30 mm. in size, was screened on 15 mm., 7 mm., and 3 mm. screens. The material remaining on each of these screens was hand-sorted into the products shown in Table I. The second-class products were subjected to the same treatment that they receive in the mill, that is, the 30 mm. size was broken to pass 15 mm., the 15 mm. to pass 7 mm., and the 7 mm. to pass 3 mm., and the materials were re-sorted. Products resulting from this treatment are shown in Table II, and the summary of the whole operation appears in Table III.

There was only one particle of first class in 1500 gm. of material on the 15 mm. screen. If the jigs treating this material are required to produce a high-grade concentrate, it is easy to see that the beds must be subjected to excessive wear while an occasional particle of the required grade is being discharged; whereas, if only tailings and middlings are produced, the beds discharge freely without appreciable wear on the particles, and a large tonnage of low-grade tailings may be released. When these middlings are re-jigged they form a uniformly high-grade bed, which likewise discharges freely with little wear.

TABLE III.
Summary

| Product | Per Cent. Weight | Assay, Per Cent. Pb |
|---|---|---|
| First Class | 3.97 | 71.8 |
| Second Class | 4.66 | 33.4 |
| Middlings | 44.63 | 14.4 |
| Tailings | 46.70 | 00.0 |
| Totals | 99.96 | 10.8 |

Tables I, II, and III show that by re-crushing the second-class product, assaying 42% lead, from two sizes, 1.5% of the weight of the whole sample was selected in a product assaying 67% lead. With a large tonnage of mill feed, and considering that this process is continued throughout the flow sheet, it can be seen that many tons of waste are thus separated from the second-class product while, in many plants, it would go to the concentrate bins. This plan of separation and selection has resulted at the Bunker Hill mills in raising the grade of the concentrate 12%, of the metallurgical extraction 10%, and of the economic extraction 11%.

## Phosphate-Rock Industry in 1918

The phosphate-rock industry in the United States may be said to have "marked time" in 1918, for the quantity of rock sold differed only about 4% from that sold in 1917. For the whole country there was a decrease in output of 93,527 tons, or 3.6%, but a gain in total value of $443,379, or 6 per cent.

The quantity of phosphate rock marketed in 1918, according to R. W. Stone, of the U. S. Geological Survey, was 2,490,760 long tons, valued at $8,214,463, as compared with 2,584,287 tons, valued at $7,771,084, in 1917. The output by states in the last two years is shown in the table.

The table shows that Florida land pebble constituted 80% of the output of the country and that the land-pebble output was 7144 tons less in 1918 than in 1917, a slight decrease. Florida hard and soft phosphate, however, increased from 18,608 tons in 1917 to 70,383 tons in 1918, or 278%. Most of this increase was made by a greater output of hard rock. The output of the state as a whole increased 44,631 tons, or 2%. The statistics for Florida were compiled in coöperation with the Florida State Geological Survey. The output of South Carolina increased about 11%, but that of Tennessee and Kentucky was 27% less than in 1917.

PHOSPHATE ROCK SOLD IN THE UNITED STATES, 1917–1918

| State | 1917 Quantity (Long Tons) | 1917 Average Price per Ton | 1918 Quantity (Long Tons) | 1918 Average Price per Ton |
|---|---|---|---|---|
| Florida: | | | | |
| Hard and soft rock | 18,608 | $8.56 | 70,383 | $7.45 |
| Land pebble | 2,003,991 | 2.65 | 1,996,847 | 2.79 |
| | 2,022,599 | $2.70 | 2,067,230 | 2.95 |
| South Carolina: | | | | |
| Land rock | 33,485 | $4.14 | 37,040 | 4.45 |
| Tennessee: | | | | |
| Brown rock | *a* 447,203 | $4.29 | *a* 374,535 | 5.12 |
| Blue rock | 65,904 | 3.12 | | |
| | 513,107 | $4.14 | *a* 374,535 | 5.12 |
| Western States | *b* 15,096 | $2.77 | *b* 11,955 | 3.53 |
| | 2,584,287 | $3.01 | 2,490,760 | 3.30 |

*a* Includes several thousand tons of brown rock from Kentucky. *b* Includes 1917: Idaho, Utah, and Wyoming; 1918: Idaho and Utah.

In the Western States also there was a proportionately large decrease—from 15,000 tons in 1917 to 12,000 tons in 1918, or about 20%. The failure of the industry to make a greater output was due largely, it is believed, to the shortage of labor caused by the war.

## Java's Trade in Billiton Tin*

The exports of Billiton tin from Java for 1918 amounted to 2185 tons, and the production was 7565 tons. In 1916, a total of 20,300 tons was produced, of which 11,500 tons went to America; and in 1917 there was produced 15,000 tons, of which the United States took 13,000 tons. Of the 2185 tons exported in 1918, the United States received 1490 tons; Japan, 381 tons; and Hongkong, 314 tons.

In a general way the price of Billiton tin throughout the year followed the market quotations for Banka tin. The government controlled the exports, and shipments were made only under license.

The following monthly quotations per picul (136 lb.) of Billiton tin, representing first cost, may prove of interest, the guilder quotations being reduced to American gold at the rate of $0.402:

| Months | Lowest | Highest | Months | Lowest | Highest |
|---|---|---|---|---|---|
| January | $60.75 | $76.18 | July | $83.01 | $96.08 |
| February | 71.96 | 80.40 | August | 93.67 | 99.70 |
| March | 78.99 | 86.43 | September | 89.45 | 95.27 |
| April | 84.22 | 91.25 | October | 89.24 | 89.24 |
| May | 86.03 | 94.87 | November | 69.95 | 89.24 |
| June | 80.00 | 87.03 | December | 60.09 | 69.95 |

The mines are worked by the Billiton Co. under a concession granted in 1852, which was extended in 1892 for a period of 35 years, thus expiring on Apr. 30, 1927. In the 1892 agreement it was stipulated that the company should receive five-eighths of the yearly profit. The geological formation of the beds on the island of Billiton, as well as the occurrence of the ore, is similar to that of Banka, but in Billiton there are tin veins that are rich enough to work.

The company has installed electrical machinery for the workings, the largest of which is at Manggar, the capital of the district, in the eastern part of the island. This station has installed two "werks-poor" Diesel motors, each of 1200 hp., with an engine in reserve. The station supplies about 800 kw. Three more Diesel motors, of 1200 hp. each, have been ordered from Amsterdam, making a total, when in position, of 7200 horsepower.

**Commerce Reports*, May, 1919.

# Notes on Flotation

By JOSEPH P. RUTH, JR.*

*A general presentation of flotation factors has the important advantage of starting discussion. Through such discussion new ideas form, and better understanding of intricate problems results. The article that follows will be read with interest by flotation operators and technical men, as it generalizes the important elements controlling flotation. Flotation depends for its success in the treatment of a suitable ore upon the delicate adjustment of not easily controlled conditions. More of the practical operators should describe their operating difficulties and their methods of overcoming them, for the information of other and less experienced operators.*

FLOTATION is not nearly so complex a process as most interested persons consider it. Flotation of mineral particles is effected by bringing several different phenomena into proper relationship with one another. The establishment of this balance between the different factors is not always easy, and it is for this reason that the difficulties of flotation arise. It will no doubt be some time before the fundamental principles underlying flotation are completely understood, but much of the difficulty of understanding the process is due to trying to understand it from investigation made of conditions in the large plant.

## Factors in Flotation

The five most important or positive factors in flotation are, in my opinion, these—agitation, the solubility of the contaminant (usually oil), the surface tension, the size of the bubbles formed, and the size of the sulphide particles. I have tried in Fig. 1 to show the interaction and interrelation of these five factors, which must all be adjusted closely with respect to one another in order to get successful flotation. The curves shown in the figure are drawn to illustrate a general condition in relation to time. Each of these factors varies according to its own laws, but, for any one factor, the other four conditions must be adjusted, and as each one of the five changes, the other four have to be changed to a greater or less degree. It is to this interdependence of the five variables that the difficulties in flotation are to be ascribed, in so far as it concerns practice. The work of Ralston, Bancroft, Hildebrand, Coghill, and others will no doubt lead in the end to a far better understanding of the physical phenomena of flotation.

The figure will be more readily understood when I state that its purpose is to show that as agitation becomes more violent, or prolonged, a greater part of the soluble portion of the oil goes into solution and an increasing proportion of the oil particles, floating in the pulp as a "reserve," is insoluble residual oil; that as more of the oil goes into solution, the lower becomes the surface tension of the bubbles; that the lower the surface tension of the bubbles becomes, and the greater the agitation, the smaller are the bubbles which are formed; that the smaller the bubbles become, the smaller is also the mass of any liftable material which these bubbles can float.

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The interrelation of these five factors or variables is complex, and it is difficult to represent them graphically. Let the operator study the phenomena as he finds time, while attending to the flotation machines in the mill. Then let him draw his own graph. The simple act of drawing such a graph will help him to crystallize his ideas the better. Finally, when he has the graph which satisfies him the best, he will find that, by studying it and considering how, when one factor is changed in a certain way, the four other factors also have to be changed if the same relative resultant or "lifting ability" is to be maintained in the cell, he will learn the better how to cope with the difficulties that are so constantly arising in the operating plant because of the many ways in which the changes in the complex conditions of actual mill work affect these five factors.

## Adverse Factors

Just as there are these five positive or helpful factors, so also are there two additional factors which by their effect upon certain of these positive or contributing factors affect adversely the flotation as a whole. These

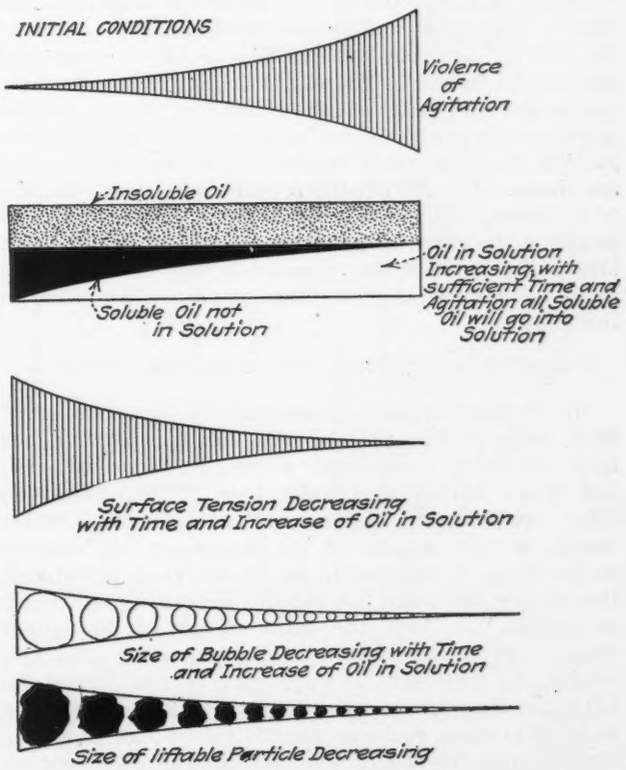

INITIAL CONDITIONS
Violence of Agitation
Insoluble Oil
Oil in Solution Increasing with sufficient Time and Agitation all Soluble Oil will go into Solution
Soluble Oil not in Solution
Surface Tension Decreasing with Time and Increase of Oil in Solution
Size of Bubble Decreasing with Time and Increase of Oil in Solution
Size of liftable Particle Decreasing

FIG. 1. COMPARISON OF FLOTATION CONDITIONS IN RELATION TO TIME

negative or interfering factors are electrolytes and colloids—the latter more probably, in most instances, fine-grained suspensions that in their behavior approximate to that of colloids, rather than true colloids. Occasionally, no doubt, the effects of these two conditions may in themselves be helpful, but I am inclined to believe that when they do help flotation it is far oftener through their negative effect upon certain of the five positive factors. In such instances they bring the five

positive factors back again into proper balance with one another by reducing the effect of some factors, rather than by their own direct positive effect upon the flotation action itself.

The greatest lifting power is that obtained when a bubble filmed with pure water is brought into contact with the liftable material. Bubbles can be formed by blowing air into pure water, but such bubbles are large in size, small in number, and lacking in persistence. The advantage of adding a contaminant (generally an oil, in practice, but it can also be a salt, and, possibly, certain colloids will act similarly to oil) is that by such addition the bubbles are rendered smaller and more persistent. For example, take a laboratory flotation machine having glass sides and capable of having the amount of air injected into the pulp in any given interval of time kept constant (my type of laboratory machine is especially adapted to this experiment, but several others can be used); put distilled water into the machine and start it. The bubbles will be relatively large. Then without altering the operative conditions in the least, except to add a drop or two of oil, watch the bubbles become much smaller almost the instant the oil is added. Moreover, the greater contamination up to a certain point, the smaller become the bubbles generated by the same amount of air and the same amount of agitation.

Referring again to Fig. 1, it will be noticed that the smaller the bubble, and the smaller the surface tension, the smaller becomes the particle of liftable material that can be floated in the cell. In other words, a particle that might have been floated by the large bubbles formed in pure water can no longer be floated. To be floated the particle must be made smaller. The reasons for this are three: (1) the smaller a particle becomes, the less is its mass; (2) the smaller the particle becomes, the larger is the ratio of its surface to its mass; (3) the larger the particle, the greater is the frictional rub upon the particle as it is lifted by the bubble through the pulp.

### Effect of Reduction in Size of Liftable Particle

Many operators fail to recognize the important effect that reduction in size of the liftable particle has upon flotation. Consider a sphere, for instance; and what follows is equally true of the cube and other polyhedrons. The surface of the sphere varies as the square of its diameter; the volume as the cube. Consequently, as the diameter is reduced, the surface decreases less rapidly than does the volume or weight. In fact, the ratio of surface to volume changes as the reciprocal of the diameter. Surface tension, or whatever the force may be that causes the lifting of floatable particles by the bubble, is dependent as to its amount, so far as any individual particle is concerned, upon the size of the surface in contact between the bubble and the particle in question, as well as upon the intensity with which that particular substance is gripped by that particular bubble film. By reducing the size of the particle the amount of surface that can be gotten into contact with the bubble is diminished. But as this surface decreases less rapidly, while the size of the particle is being reduced, than does the mass of the particle, and therefore than does also the pull of gravity upon the particle (which is one of the principal forces opposing flotation), the size of the particles in the pulp can be reduced until the diminished flotative power of a unit area of bubble surface (reduced in intensity because of reduction in intensity of the bubble's surface tension by the oil added as contaminant) is again capable of floating the liftable material under the new conditions that have been set up.

That is one effect of reduction in size of a liftable particle upon its flotability. Another gain rises from the fact that as the bubble begins to move with its load the resisting force of friction begins to oppose its rise. This frictional resistance is twofold in its nature. First there is the mechanical rub of the pulp upon the bubble; second, there is the viscosity or internal resistance of the pulp liquid to displacement that must be overcome. The smaller the particle, the less will be both kinds of frictional resistance. Therefore, the smaller the particle, the less likely it is to be brushed off a bubble while the pulp is being agitated.

Unfortunately, as the size of the valuable mineral is reduced for any given grade of ore, the greater becomes the number of particles that must be brought into contact with the bubble surface if they are to be floated, and so the greater, other things being equal, becomes the difficulty of saving the valuable mineral from the gangue. In fact, it is possible, although many do not seem yet to appreciate it, to grind the pulp so fine that it is impossible to make an efficient recovery upon it by flotation. In other words, just as years ago it was found that an ore could be ground too fine for efficient gravity concentration, now it has also been found that to a certain degree the fact also holds true in flotation.

### Probability of Contact

The probability that all the liftable particles in the pulp will be brought into contact with bubble surface is a function mainly of the ratio of total bubble surface to the amount of the surface of liftable particles that must be floated. The smaller the individual bubbles, the larger is the total bubble surface obtained for any given volume of air put into the bubbles. The flotative efficiency of any contaminant is, therefore, to a considerable degree a question of its effect relatively both upon the surface tension of the bubble film and upon the strength of that film; for upon the strength of the film depends the size to which the bubbles can be reduced without their coalescing immediately when they come in contact with one another during agitation of the pulp.

Not only can the probability of contact be increased by increasing the bubble surface, but also by lengthening the time during which contact is possible. Decrease in the size of the bubbles decreases the rapidity with which they rise through the pulp, for the smaller the bubbles the greater is their surface in proportion to their displacement, and so the larger becomes the relative frictional resistance of both the liquid and the suspended gangue particles to the rise of the bubbles through the pulp. Consequently, the greater also becomes the probability that the bubble will become loaded with liftable particles, and, of course, the heavier the load that is carried by the bubbles the slower will they rise through the pulp.

One of the most important points in the design of a flotation machine is this matter of promoting probability of contact not merely between bubble and pulp, but between bubble and sulphide particle in the pulp. Bringing the bubble and the sulphide particles efficiently into contact with one another, and the obtaining of proper aëration of the pulp, are the principal points in the

mechanical aspect of the process. Too little importance had been given to these two phases of the problem in the design of the various flotation machines on the market.

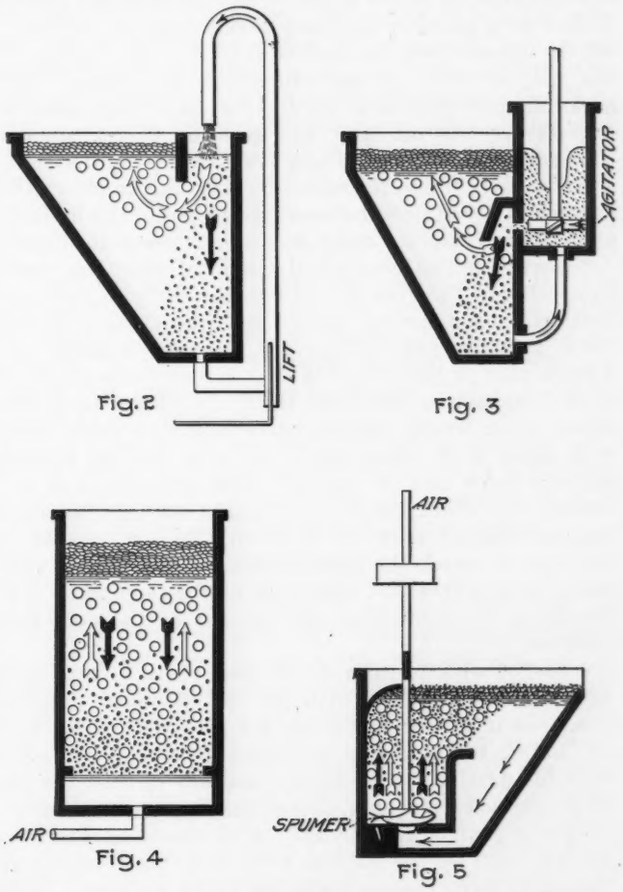
### Action of Flotation Machines

Fig. 2 shows in diagrammatic section a rather common type of flotation machine. The cascade type of machine and those types in which an air lift or centrifugal pump is used to circulate the pulp through an exterior chamber come within this general type, so far as pulp and bubble travel are concerned, for in these types of machines the pulp is withdrawn from the bottom of the cell and enters it again at the top behind a baffle so as not to disturb the bed of froth that is cleaning itself in the collecting chamber of the machine.

The difficulty in flotation is to catch the heavier and larger particles of valuable liftable mineral. Consider what happens to these particles in a machine of a general type as shown in Fig. 2. It is known that the tendency of matter is to continue its motion in the direction imparted to it unless influenced by some other force. The finer particles in the pulp tend to lose their velocity rapidly after they get away from the confined space behind the baffle and enter the cell proper. But the coarser particles of the pulp, and especially the sulphide particles, tend to keep on sinking and to circuit directly down to the draw-off opening in the bottom of the collecting chamber. On the other hand, the bubbles, as shown by the skeleton arrows, begin, because of their buoyancy, to rise to the surface of the pulp just as soon as they have got outside of the more intense influence of the current near the baffle board and before the suction that is drawing the pulp to the discharge opening can exert control over them. Owing to this short-circuiting of the bubble air back to the surface by way of the froth bed, the time that the bubbles are in that part of the pulp path where they can come in contact with the coarser particles of sulphide is comparatively short, considering the length of the total path followed by the pulp. In other words, the pulp in such types of flotation machines has to pass through the circuit more times in order to get contact with the coarser particles than would be necessary were the bubbles and pulp traveling together in the same direction for a greater distance through their respective paths.

In Fig. 3 is shown a diagrammatic section of a paddle-wheel type of agitator. The same general criticism applies to this type as to the one shown in Fig. 2. But there is still another disadvantage attending the use of these two types of machines. That is the scrubbing effect which the pulp has upon the bubbles as they begin to lag behind, and then to rise through the pulp. This scrubbing and impingement of the gangue particles upon the sulphide load carried by the bubbles tend to tear off from the bubble surface those particles of such low liftability, because either of size or inherent nature, that they are just being held by the bubble. These particles must then go around the circuit again if they are to be caught, and then, possibly on the second passage through the critical zone, they will be torn off the bubbles and fail to be lifted up into the froth bed where they will become comparatively safe. Prolongation of the baffle board will aid somewhat in meeting the first of these objections, but, because of the greater confinement of the current, and its inability to dissipate itself in the body of the collecting chamber before the pulp particles come within the influence of the suction at the bottom of the cell, the second objection becomes more cogent than before. The principle is wrong, and so a compromise is the best that can be effected in overcoming the difficulty.

Fig. 4 is a pneumatic machine of the mat type in diagrammatic section. In this type of flotation machine the general direction of travel of pulp is across the direction of rise of the bubbles in the machine. It would appear, at least at first glance, that the difficulties mentioned in the preceding paragraph were obviated. But this is more apparent than real. The truth of the matter is that the actual travel in such machines consists of an up-and-down, slowly progressive movement of the pulp particles through the machine. The bubbles displace liquid at the bottom of the cell. As they rise, pulp from




FIGS. 2, 3, 4, 5. ACTION OF FLOTATION CELLS

above must come down to fill the space which they occupied, while at the same time the air bubbles tend to draw along behind and with them a certain minor amount of pulp. This sucking action tends to make the bubbles coalesce with one another, thereby reducing the amount of bubble surface and in that way decreasing the probability of contact with the sulphide particles per unit volume of air used to form bubbles. In its downward movement the pulp tends to scrub the sulphide particles off from the bubble surface. This scrubbing action is, if anything, even more severe than in many other types of machine, and is especially hard upon the larger sulphide particles that have become attached to bubble film. In fact, it is probable that in many of the mat pneumatic machines the loading of the bubbles with sulphide particles occurs largely at the bottom of the froth bed where the pulp is whipped up against it, and

where, owing to the rapid rise of other bubbles, the mineral-laden froth is soon pushed out of range of the pulp's rub. This whipping of the pulp against the bottom of the froth bed tends to give certain compensating efficiency to the mat type of machine. But it is also evident that the larger particles of sulphide cannot be lifted up to the top of the pulp bed without resort to excessive formation of bubbles and the lifting of a rather dirty concentrate, at least in the rougher cells. In this explanation of the manner in which the froth is mainly loaded with sulphide particles in the mat type of pneumatic machine, the reader will find the reason why such machines cannot be made to treat coarse pulp as efficiently as is possible with a paddle machine.

Fig. 5 shows a diagrammatic section of another flotation machine. In it the agitation and aëration are accomplished by a specially designed device called a "spumer." Air is sucked down the hollow shaft by the rotation of the spumer while at the same time the spumer also sucks air and pulp up from the bottom of the collector chamber of the machine. The rotation of the spumer thus throws air and pulp out, practically together, with a vortex motion into the agitation chamber, causing good contact to be obtained between the pulp and the bubbles, as both are traveling along with one another at slightly different velocities, owing to the buoyant effect that tends to accelerate the rise of the bubbles through the pulp until they have become fairly well loaded. As both sulphide particles and bubbles are traveling together for a large part of the circuit, and as the sulphide particles have a momentum that takes them along with the bubble travel, much larger sulphide particles can be floated than with other types when using the same surface tension and the same size of bubbles. Moreover, there is less tendency in this type of machine for the pulp to scrub the particles off from the bubbles. This is because of the way in which the bubbles tend to rise with a relatively slow differential speed out of the pulp while it is travelling horizontally across the top of the collecting chamber.

I do not wish to infer from these remarks that good work cannot be done with all the standard flotation machines if proper conditions are obtained. What I do say is that the obtaining of contact between bubble and sulphide particles is necessary in order to float the sulphide particles, and that, therefore, the greater the probability of contact and the less the likelihood of scrubbing the particles off the bubbles after they have become attached to them, the more efficient is the machine. Moreover, to get flotation with other machines, the sulphide particles must be crushed finer than is necessary to float the same mineral when the pulp and the bubble flow are in the same direction. This is a considerable advantage, it seems to me, for the finer the particles into which any given amount of sulphide mineral is crushed, the greater is the number of particles that must be brought into contact with bubble surface, and, therefore, other conditions being equal, the greater becomes the difficulty of catching all of them.

### Size of Bubble

The size of the bubble is important for three reasons: (1) the smaller the bubbles are, other things being equal, the less rapid is their rise through the pulp; (2) the smaller the bubbles, the less is the tendency for them to coalesce when they come in contact with one another; (3) the more uniform the size of the bubbles is, the less is the tendency for them to coalesce. Coalescence of bubbles is undesirable because of decreasing efficiency of the air per unit of volume put into bubbles, and on account of the commotion that coalescing, or "blebbing" action, produces in the pulp.

Naturally the question arises as to how the size of the bubbles can be regulated. In the first place, the larger the proportion of oil in the bubble surface, the smaller the bubble becomes, other conditions being kept constant. With the amount of oil or contaminant constant, the size of the bubbles that are generated depends upon the speed at which the air is put into the pulp and the rapidity at which the pulp is forced through the aëration zone. The smaller the amount of air fed into a unit volume of pulp, the smaller are the bubbles that are formed, and the greater the speed at which the pulp is traveling through the aëration zone, the smaller the bubbles are for any given feed of air.

### Flotation Oils

Much has been said about the amount of oil used in flotation, and much attention has been given to the results that can be obtained with different oils. In my opinion one oil is about as efficient in flotation as another. The whole point of the oil problem, is, I believe, to get the oil adjusted in solubility to the violence of agitation resorted to in the treatment of the pulp. The less violent the agitation, the more soluble the oil that must be used to obtain the best results on any ore. The more violent the agitation, the greater is the proportion of insoluble oils which must be mixed with the soluble oil to maintain proper flotative conditions within the cell.

Referring to Fig. 1, in which I have attempted to picture the relationship which exists between the five positive factors in flotation, the reader will appreciate that it is necessary to keep the amount of soluble oil or contaminant in the pulp constant throughout the machine. He will also realize that the more violent the churning which the oil and pulp receive, the more rapidly will the soluble portion of the oil go into solution. Whatever oil may be in solution tends to go largely and rapidly into bubble surface. The bubbles as they pass into the froth bed take the oil within their films out of the pulp. Consequently, in order that the films of the next series of bubbles may have the same surface tension as that of those formed the instant before, an amount of oil must have gone into solution equal to that which went into the bubble surface during the same interval of time. That this feeding of oil to the pulp may go on constantly, throughout the machine as a whole, in proportion to the amount of oil that is passing out of the pulp liquid into bubble film, a reserve of oil must be scattered through the system, and this oil must be so proportioned as to solubility that it dissolves at just the right speed to maintain proper flotative conditions in the cell. If it were not for this properly proportioned reserve of as yet undissolved oil scattered through the pulp, the surface tension of the bubbles would vary greatly in different parts of the machine, and so, as in all other respects the conditions in the several cells are similar, the flotative action in some part of the machine would not be kept at as high efficiency as in others.

It therefore follows that too violent agitation makes it impossible to keep a constant condition of contamination throughout a series of cells. By mixing the contaminant oil with a more or less viscous insoluble oil, the rate of solution of the contaminant is diminished and constancy of conditions increased.

# Repair Work in Milling Plants

By CHAS. LABBE*

*It is important that expenses in making repairs in milling plants be kept at the lowest possible figure. Of course, extensive repairs often call for renewals and transformations, but the present high cost of new machinery makes the repair crew an important adjunct. Repairs are due principally to wear of the machinery. Accidents also occur and necessitate repairs. Many transformations and improvements are included under the heading of repairs. They are not repairs proper, but in the great majority of cases they are made by the same crew and charged to the repair account. An outline of repairs can be made by following the mill flow sheet.*

WHEN hard pieces of ore wedge themselves between the bars of the grizzly and are continually driven in by ore falling upon them, bending of the bars results, making the spaces unequal. They can be straightened with a crowbar and a ratchet jack, the foot of the latter resting on the sides of the chute. By changing the jack from one side to the other a quick adjustment can be secured, so as to reach every bar. The bars may be worn down so far that they have lost their strength and are bent downward. The only remedy would be to replace them, or, at least, replace a worn bar by a new one. The sides of the chutes may have to be relined in those places where heavy rocks are dumped.

Planking does not last long, and pieces of sheet iron must be nailed or bolted to the sides. The same work may have to be done in the bins, but here a lighter sheet iron can be used, a No. 26 or 24. It helps a great deal to keep down wear, and the ore slides much easier than on rough wood. Inside next to the gates a heavier sheet iron must be used, No. 10 to 16, often reinforced with discarded rails or flat iron such as old wagon tires which have been straightened.

In mills where shooting is done in the ore bins the repair crew usually has to work overtime. Large and heavy sheets become so warped and buckled or swollen out of shape that they must be taken to the blacksmith shop. The warping is straightened on a large iron block with hammer and flatter. For the swelling, a small hole is drilled (with diameter the same as the thickness of the sheet) at the highest part, the damaged place heated red in the forge and hammered down following the contour of the hump, starting near the foot and spiraling toward the hole. As the metal expands, the hole will be nearly closed when the work is finished. If it must be waterproof, a touch of the oxyweld flame or a small rivet will finish the job.

## Belt Conveyors and Elevators

The belt conveyor from time to time requires the replacement of rollers, shafts, and bearings, and damaged or out-of-order grease cups, and while these repairs are being made there will be a good opportunity to line up several rollers, and add or remove side rollers. All rollers must revolve freely, and one must make sure that the grease reaches them. Remove all dust or ore which has accumulated in the front of the rollers. It may be necessary to take up the belt. Move the take-up bearings as far in as they will go, put the belt clamp on at about the length of the conveyor, and cut off as needed. Sometimes the belt breaks and the ends fly 50 ft. apart. A small belt can be brought back by hand, but for an 18- or 24-in. belt a 1-in. rope must be used, made fast with four to six timber hitches on each side, and, with a rope block, the ends should be brought back as close together as possible, so that they may be handled with the belt clamp. Patches can be put in with belt lacing where needed, care being exercised to see that they do not protude over the outside edge. The lacing should be put in so that the smooth side is on the running side. All the roughness must be on the carrying side. Patches put in with ordinary care do not affect the straight running of the belt.

## Elevators

Wherever there are elevators, repair mechanics are needed. No matter where the mill is put, be sure to get all the fall necessary for the continuous downward descent of the ore. The buckets wear and need replacing. Dry or wet, there is always a quantity of leakage, which causes a rapid wear of chain links, pulleys, and bearings. Always provide the elevator boot with a discharge gate at the bottom, and place the boot where it can be emptied by simply opening the discharge gate. Accessibility in this case will mean a great saving in time later.

## Crushers

Rock breakers are usually designed to stand all the work they are to perform, which is the hardest in milling plants. Wear takes place in the bearings and on the breaking jaws. All the bearings are babbitted, and when worn down they must be rebabbitted. Use only the grade of babbitt made for that purpose. Many babbitts are either too soft and do not stand the pressure, or are too hard and brittle. In most crushers the crushing jaws can be changed end for end. When worn at one end, which is mostly the lower end, taper bolts must be drawn very tight; and if the jaw plates have a chance to move sidewise it is best to wedge them tight, or, better, pour zinc to keep them in place. If the pitman cap studs break often this is caused by the back toggle being set on the wrong slant. The toggles must point down toward the pitman, and worn toggle and toggle seats must be taken out and overhauled at the machine shop. There must be plenty of head room at the crusher, and a crawl with chain block similar to the one over the stamp batteries must be installed even before erecting the crusher. Such an installation will pay for itself at the first repair. Over large crushers it is imperative.

In the gyratory rock crusher a common repair is the babbitting of the eccentric. A special sleeve is always provided, thus simplifying the job. The old babbitt is chiseled or melted off, the sleeve clamped on and the babbitt poured in. As soon as cool, the sleeve is removed and the oil grooves are cut. The concaves must be replaced when worn to a safe limit. To take them

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out, the first one (which is the hardest) must be shot out with powder by boring a small hole in the zinc. Sometimes blasting can be avoided if by careful examination a loose concave can be found by trying with the hammer, the zinc chiseled off so as to let drive a sharp moil, and then a crowbar used. To put in new concaves, a guide ring is often used, which facilitates the work. If none is at hand, each concave is braced to the head with a strip of wood. Clay softened with oil is used (as in general babbitting work) to prevent zinc from running out. Be careful that no foreign matter drops between the concaves, as it will impair the strength of the zinc and make boiling certain when pouring. The concaves will set tighter if they are heated before pouring.

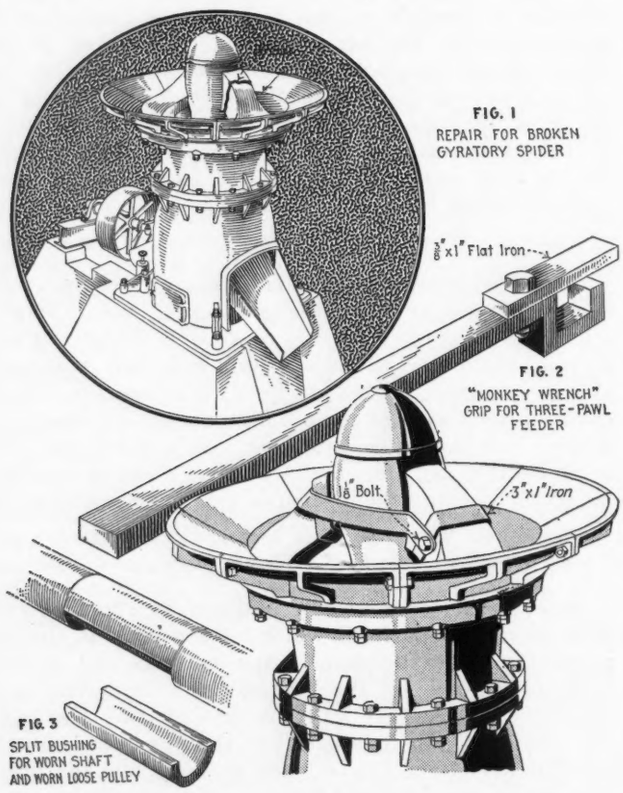



FIG. 1
REPAIR FOR BROKEN GYRATORY SPIDER

FIG. 2
"MONKEY WRENCH" GRIP FOR THREE-PAWL FEEDER

FIG. 3
SPLIT BUSHING FOR WORN SHAFT AND WORN LOOSE PULLEY

QUICK REPAIRS OF MILLING MACHINERY .

To take up the wear and to keep the crushing uniform, the shaft is raised, but when the lower edge of the crushing head comes above the lower edge of the concaves nothing can be gained. Either the concaves or the head must be changed. To take the head off, it is best to remove the entire shaft to the machine shop, because, as a rule, it is tight, and often the hydraulic press must be used.

In some crushing plants a duplicate shaft is kept with a different head. The one already used is put in when a new set of concaves is placed, and when the concaves are somewhat worn the shaft with the new head is put in. Thus the adjustments for uniform crushing are easy and a head can be changed at the shop when convenient.

A tedious repair is the replacement of a broken shaft, and a broken spider is as bad, if not worse, as a clamp must be forged in place to fit around one arm near the shaft bushing, another clamp fitted at the lower part of the broken arm, and a strong draw bolt put on each side. But in places where big rocks hit the spider, bolts must be omitted. A piece of flat iron is heated and bent in place around one arm, extending to the lower part of the other arm; then both ends are fastened with a bolt, as shown in Fig. 1. The heat must be kept on the sides of the clamp while tightening the bolt. In cooling, the contraction brings the broken parts together.

### Feeders

Nothing is more troublesome to the mill man than an unreliable feeder. The principal cause of trouble is lost motion. In the three-pawl friction grip, the bars and blocks become worn and often drop out. A piece of light iron, $\frac{1}{16}$ by $\frac{3}{4}$ in., bent on one end, will help in taking up the wear, but, as a whole, this three-pawl grip is being replaced by the "monkey-wrench" grip, which is, in every particular, simpler and more satisfactory, being easily made with a piece of pick steel. Still better is the one which has a small loose wedge of hard wood which can be taken out and replaced easily and quickly when worn.

### Rolls

To keep rolls in good working order it is necessary to maintain the roll shells in a smooth, straight shape. The corrugations are caused by an incorrect speed and an uneven feed, and they are fewest in rolls fed with an automatic feeder which delivers an even stream of ore over the entire width of the roll face. When rolling down the spout a classification of the material takes place. The large pieces bounce toward the edges, and those of small size fall directly in the rolls. To prevent corrugations and flanging, the whole shaft and roll is adjustable endwise by a collar or nuts and washers.

When no feeder is used, an adjustable deflection plate can be bolted in the hopper (all the bolts provided with lock washers or cotter pins to prevent their loosening and falling in the rolls), directing the ore toward the high places of the rolls. A simple device also used is a frame holding two or three carborundum bricks, usually 3 in. square and about 6 in. long. They are placed in the top housing and ride on the roll, their own weight being sufficient to wear off the ridges.

Sometimes with hard ores and soft-spotted shells it is necessary to true the shell surface in the lathe or in place. If done on the lathe the whole roll and shaft must be taken out, whereas if done in place the top housing is removed, two square pieces of steel are bolted on the frame, and a lathe compound rest with tool holder is clamped on the bars, the speed reduced by using a 1 or 2 hp. motor, back geared and belted to the large pulley of the roll. To change a roll shell it must be remembered that the hub is made of two flanges—one tight and one loose. The loose one must be forced out by three or four bolts and some pounding. Often the shell must be heated by coiling old rope around the outside, soaked with waste oil, and lighted.

The bearings may need rebabbitting. This can be done in place or in the machine shop and bored out to size; but care should be taken that the oil grooves are of ample size. It is advisable to leave an empty space on the side where the shaft exerts no working pressure, and to have such space filled with loose hemp or flax, or, still better, with woolen waste resting in oil. This provides an abundant supply of oil to the journal and at the same time wipes off any dust or rock which may have found its way into the bearing. The dust-proof covers must be examined periodically.

Much has been written about the repair of stamp mills, but a few words here will not be out of place. The mortar

block may need replacing, and in that case the stamps must be raised as high as possible, the mortar either hung up with chains to the camshaft and post or moved out of the way. A templet must be made while the old block is in place, and corrections noted on the templet. The old block is then taken out and the muscles exercised at the concrete mixing until the mortar block is at correct height. Give to the concrete ample time for setting. As a block of such size cannot set properly in less than two weeks, there will be ample time to ascertain if the camshaft is level.

If the camshaft boxes need rebabbitting it must be done. Tappets or boss heads may have to be changed, and stem guides overhauled. The bull wheel may be loose on the shaft, or the belt tightener may need some repairing. I will not mention screen frames, as there should be a good supply on hand ready to be put on at a moment's notice, but the line shaft must be tested for alignment. The battery posts and stems must be checked to see if they are plumb on two sides, and nuts and bolts attended to. A finger jack may need a new handle, or the carrying edge may be so battered and short that the piece of wood must be replaced. I mention camsticks made of discarded rubber belting. They will last much longer if a piece of strap iron about 1 in. wide and about $\frac{1}{16}$ in. thick is fastened lengthwise over the wearing part.

### Tube Mills

One of the main repairs of the tube mill is the relining. Less time is needed to replace metal lining than silex or rock lining, and it is favored now in the majority of mills. It is more satisfactory in the long run. Where freight costs are high and time is likely to be lost in waiting for the proper setting, the silex lining is not to be favored. While running, some of the lining may fall off, and cemented patches are unreliable. In the steel-plate lining the wear is more even, but considerable wear is first apparent on the countersunk bolts, which is soon noticed by leaks, and such bolts must be replaced. All leaks must be attended to at their first appearance, as in running they keep increasing. To make a leak-proof bolt, place the bolt in place, tighten it up so as to be sure that the nut and washer go as far as needed and that the head is drawn up. Then back up the nut and washer one thread or two threads, *not more*. Wrap the wicking or rope (swabbed with asphaltum paint) tight around the bolt, tighten up the nut, and it will not leak.

The feeder scoop may need some repairing. If side plates must be replaced, it is best to send the whole scoop to the shop and put an extra one on. Patches can be put on while in place, either with holes drilled and bolts, or with the oxyweld. The wearing point of the scoop must be of soft steel, either cast or forged, and the sharp point a piece of chrome or manganese steel, welded on. This makes an unbreakable and lasting point.

Some tube mills have a discharge of the closed type fitted with a plate or screen for retaining the pebbles. The grate type has the advantage over the drilled holes in that it permits the use of a thicker plate. The slot shape is self-clearing while revolving, whereas with the round holes any piece wedged in must be punched out. Ascertain how much the lower half of the trunnion bearings is worn down. The babbitt lining may have to be changed for a new one. Test the drive shaft for alignment and inspect the pinion and key.

Mention will be made only of the drag type of mechanical classifiers, although the other types placed in the tube-mill circuit wear in the same way, which is noticed on the ends of the rakes or edges of spirals. With all, the purpose is the same—to bring back the oversizes. In the drag type the pieces of angle iron will probably have to be replaced. The easiest way to do this is to disconnect the frame from the rods and links and to hoist the frame out with rope blocks. Place it on a flat car and run it to the machine shop, where there will be room and tools to cut the rivets off. Put new pieces on. If only one or two pieces were loose or out, a new one can be put in place with bolts without taking anything apart. While the rake is out, clean the classifier tank. Sometimes the bottom has iron and sands cemented together, forming a floor equal in hardness to an emery block. The cams may have to be replaced; also the rollers and pins. Bearings may need babbitting, but it is easier to take them out and put new ones in than to babbitt them in place.

### General Repairs

The concentrators may also have to be repaired, but it is mostly the replacement of a worn-out part—simply to take the old piece out and place the new one in, and a slight readjustment of the table.

There are other repairs, such as a worn, loose pulley, which may also have worn the shaft. In such case the shaft has to be put on the lathe and dressed true. If the pulley had a bushing, a new one must be made, or it may be that the pulley had no bushing and the original bore is worn out of true. Then the pulley is rebored and a split bushing made to fit pulley and shaft. A bushing may be worn, but available for further service by a little tightening. This can be done by taking it out and dipping it in solder or babbitt, or the bushing may be split with the hack saw, a piece of tin can wrapped around, and the whole pressed back into place.

A pulley can be enlarged so that the repair will not cost more than a new one. The small ones (such as motor pulleys) can be made larger by gluing paper on them. Larger ones can be increased by wrapping belting around, held with elevator bolts, but this should not be carried to excess. Two to six inches can be gained by bolting strips of wood across the face of the whole circumference. Before use the face must be trued up either on the lathe or in place. Pulleys can be made 8 to 16 in. larger by using a piece of sheet iron or the rim of a pulley of the size wanted and putting studs and nuts radially in the original rim. In this way the new rim can be centered and trued up, by screwing or unscrewing the studs, and when finished they can be riveted on or welded on with the oxyweld.

There is room for improvement in the design of bearing boxes. Why not make them with removable die cast liners, the castings simply bored out and faced on both sides to standard sizes? Also in many places roller or ball bearings could be used with great advantage. Their first cost presents the chief difficulty. There would be a big market for them if they were made cheaper and in standard sizes. I believe a fan, dynamo, or the pedestal bearings of centrifugal pumps can be constructed with ball bearings and a saving effected in oil and power. I do not see that they have to stand harder work than the front wheel of an automobile. In the future, I feel sure that the designer will ask the repair man about some details, but when I realize that the hoist, compressor, pumps, cyanide plant, and engines have to be repaired, excuse me, but I must go and get busy.

# Working Adjustments of the Wetherill Magnetic Separator

By GEORGE J. YOUNG

THE general features of the Wetherill separator are sufficiently well known to make it unnecessary to describe them in detail here. Fig. 1 indicates the more important magnet adjustments. The description that follows applies to a 4-pole machine provided with a 6-in. feed belt. Adjustments which the operator can make, and the method of making them, are relatively simple, but require judgment. The lower magnet of each pair can be raised and lowered to a limited

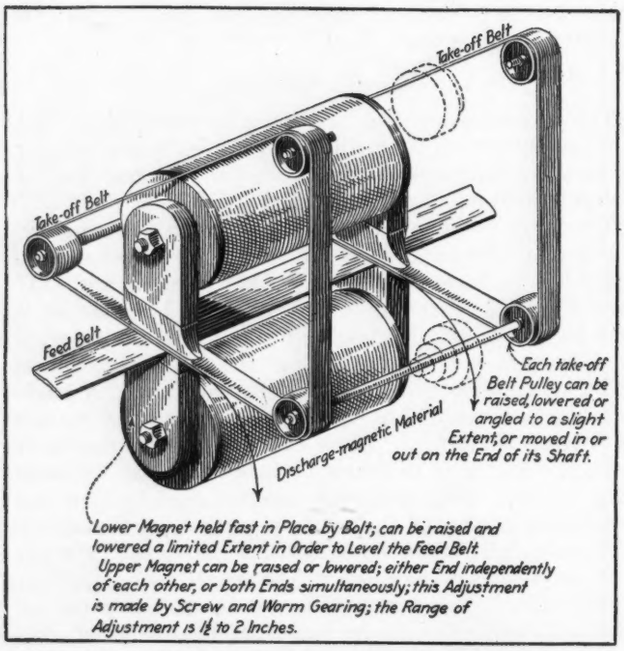

Take-off Belt
Take-off Belt
Feed Belt
Each take-off Belt Pulley can be raised, lowered or angled to a slight Extent, or moved in or out on the End of its Shaft.
Discharge-magnetic Material
Lower Magnet held fast in Place by Bolt; can be raised and lowered a limited Extent in Order to Level the Feed Belt.
Upper Magnet can be raised or lowered; either End independently of each other, or both Ends simultaneously; this Adjustment is made by Screw and Worm Gearing; the Range of Adjustment is 1/4 to 2 Inches.

FIG. 1. ADJUSTMENTS OF WETHERILL SEPARATOR

extent, and the adjustment is necessary in order to make the feed belt level or to eliminate a hump caused by one of the lower poles being too high. Once the adjustment has been made, the lower magnet should be bolted firmly in position, because the upper will lift the lower magnet if the bolts of the latter are not tightly secured. The upper magnets are raised and lowered by means of a worm gearing, operated by a sprocket chain and a hand wheel. Each end of a magnet is provided with an independent adjustment attachment, and, within certain limits, either pole of an upper magnet can be raised or lowered. The adjustment is required for increasing or decreasing the pole distance.

Each pair of magnets (upper and lower) is provided with an ammeter and a rheostat. The resistance of the rheostat is divided into a sufficient number of parts to make the current increment for a shift of the handle of the rheostat, one button, quite small. By means of a suitable field rheostat in circuit with the d.c. generator, the current to each magnet can be regulated within any reasonable limitations; but, necessarily, the allowable maximum current should not be exceeded.

The feed belt is driven by a step pulley which permits of four speeds, a range more than sufficient for the work that the machine is called upon to do. Slack in the feed belt is taken up by a tightener, and this adjustment must not be neglected. The feed hopper is provided with an adjustable gate and feed sole, so that adjustment may readily be made. For a coarse feed, down to 30 mesh, the feed sole can be left in its lowest position, but for a fine feed it should be raised until a smooth feed bed results. It can then be wired in proper position.

The take-off belts are of thin, smooth rubber. They are provided with step pulleys, and can be driven at three speeds. For some kinds of work I am of the opinion that a belt with fine transverse corrugations would give better results; and experimental machines, at least, should be provided with them, as well as with the smooth belts. The take-off belts are provided with adjustments so that they can be slightly raised or lowered, shifted from side to side, and tightened. It is necessary to have the belts lined upon and symmetrically placed with reference to the pole pieces. The belt should be moderately taut. Sometimes trouble with the take-off discharge can be remedied by slightly loosening the take-off belt. The portion passing under the pole piece should be horizontal and should touch the pole piece lightly.

The upper pole of a pair of poles is made wedge-shaped, and the lower is rectangular in section and flat. The maximum field is from $\frac{1}{2}$ to $\frac{3}{4}$ in. wide by 7 in. long.

## Pole Distance and Amperage

Pole distance is one of the most important adjustments, for upon it depends the satisfactory operation of the take-off belts, the cleanness of the products, and the effectiveness of the separation. The nearer the poles are to each other, the greater the concentration of the magnetic field for a given amperage. If the poles are too close, the magnetic material clinging to the take-off belt will brush across the bed upon the feed belt and carry non-magnetic material into the discharge of the take-off. On the other hand, if the pole distance is too great, the magnetic material will pass through a relatively greater vertical interspace, and a better opportunity will be afforded for the non-magnetic material to drop back upon the belt from which it was lifted with the magnetic particles. It is impracticable to use a great pole distance, even with an amperage sufficient to lift the magnetic particles, because the take-off belts do not discharge properly under such conditions. With coarser material a greater pole distance can be used than with fine. Minimum pole distance ranges from $\frac{1}{8}$ to $\frac{1}{4}$ in., measured above the feed belt, and the maximum is 1 in. Fig. 2 illustrates the relation between the six poles of a three-magnet separator.

By the use of the rheostat and suitable current connections, the amperage upon a magnet can be varied from 0.05 to 6. This affords sufficient range for most of the conditions that a separator will be required to meet. In making the amperage adjustment, it is best to start with a small current, 0.1 ampere on each magnet. The current to each magnet can be increased gradually after starting the feed and the work that it is doing

judged by the discharge from the take-off belt. Excessive amperage will be indicated by a bunchy and intermittent discharge.

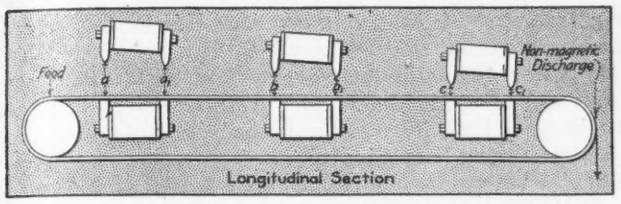



FIG. 2. ADJUSTMENT OF SIX-POLE SEPARATOR

The various conditions with which the operator will have to cope are illustrated in Fig. 3. A normal discharge is shown by *A*. The stream of material has the appearance of a thin, slightly curved rod. In *B* the stream of material drops with a greater curve and sprays out more than in *A*. This condition may be due to too low a speed of the take-off belt, too high an amperage, or too great a pole distance. In *C* the take-off stream drops sharply, and part of the material returns to the belt. The portion which is discharged falls in masses. Excessive amperage usually causes this condition. In *D* the magnetic material collects in a nebulous mass in constant motion below the horn of the upper pole. After a certain volume has collected, a portion is discharged. Both excessive amperage and pole distance cause this condition. In *E* the magnetic material bridges across the poles at a point beneath the take-off horn. Material of high magnetic permeability under high amperage will act in this manner. So tenaciously does the bridge form, that the take-off belt will be stopped.

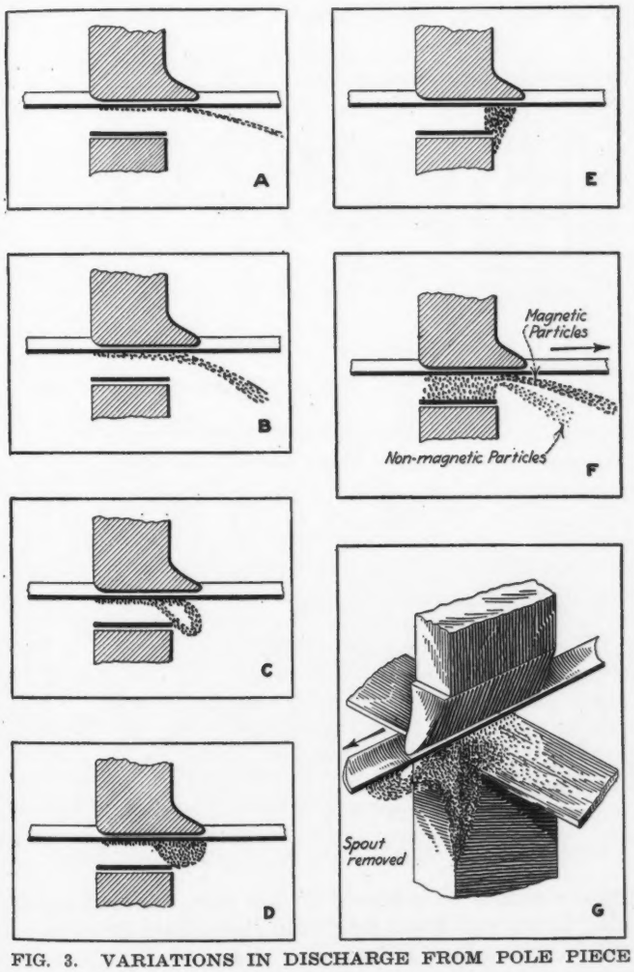



FIG. 3. VARIATIONS IN DISCHARGE FROM POLE PIECE

An aggravated case of excessive pole distance and high amperage is shown by *G*. The magnetic material builds up on the corner of the lower pole from the "boiling mass" just beneath the discharge horn. In this position it pushes the non-magnetic material off the belt and "drips" down below the lower magnet.

The condition represented in figures *C*, *D*, *F*, and *G* is readily explained. A magnetic particle on the feed belt is lifted to the upper magnet pole, but is prevented from touching it by the take-off belt. The take-off belt pulls the particle to one side and eventually out of the strongest portion of the field. If the force in the direction of the take-off is strong enough, the particle will be thrown a sufficient distance so that there is no danger of return. Increase of amperage with a given pole distance increases the force of the magnetic field, and often to such an extent that the particle is drawn back before it can fall into the discharge hopper. The force exerted upon the field must be just strong enough to lift the particle to the take-off belt, and any increase interferes with the proper discharge of the magnetic particles. Particles of low magnetic permeability will discharge properly, even if the magetic field is excessive. Increase of the pole distance diffuses the magnetic field over a larger area, and this tends to cause strongly magnetic particles or very small particles to return to the field.

Fig. *F* represents a condition caused by an excessive amount of magnetic material removed by one belt. A stream of non-magnetic particles is pulled off with the magnetic ones. There is a practical limit to the capacity of the take-off belt, and if this is exceeded the non-magnetic product is contaminated. Sweeping also takes place under the same conditions.

### Speed of Take-Off Belt and Thickness of Feed

The take-off belt must develop a sufficient horizontal component to propel the magnetic material out of the field. For strongly magnetic material the highest speed is essential, whereas for weakly magnetic minerals a lower speed may be sufficient. Take-off capacity is also determined by speed, and where there is a large burden of magnetic material the highest speed is necessary.

Too thick a bed on the feed belt causes a disturbance beneath the take-off belt and results in non-magnetic material being discharged with the magnetic. It also causes some of the magnetic material to be discharged with the non-magnetic. For good separation a thickness from 1½ to 2 grains high is desirable.

### Speed of Feed Belt and Uniformity of Feed

With a given thickness of bed, capacity is determined by the speed of the feed belt. Too high a speed produces dust and does not allow sufficient time for some materials to react to the magnetic field. The width of the maximum field is from ½ to ¾ in., and at 30 ft. per min., the lowest speed, the time interval is 1/12 sec. for the passage of this narrow strip. At 90 ft. per min. the time is 1/36 sec. At the minimum speed, the magnetic particles begin to rise before they reach the magnetic field, but at the maximum speed, 110 ft. per min., the particles pass the magnetic field and are pulled back as shown in Fig. 4. This applies to highly magnetic substances such as iron filing. It is evident

that with minerals of low magnetic permeability, consideration of this time interval is even more important. With weakly magnetic material, low speeds are desirable, and with highly magnetic, high speeds are not objectionable. Experimental runs indicated the largest crops of magnetic material at the slowest feed-belt speeds.

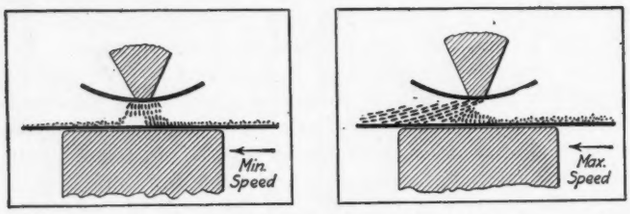



FIG. 4. ACTION OF MAGNETIC PARTICLES AT DIFFERENT SPEED RATES

Uniformity in feed rate produces a bed of uniform thickness and is essential for good separation. Too great disparity in the size of the material particles must be avoided to secure this. Sizing is essential in most cases, but numerous sizes, such as would be required in dry concentration, are not necessary. The material must be thoroughly dry. Certain minerals develop a tendency to stick and hang in the feed hopper. As a rule roasted or magnetized ore will feed satisfactorily, even though finely divided. If it is necessary to crush the material, it should be done before roasting.

Differences in magnetic permeability of the minerals and compounds to be separated are important as affecting the adjustments of the separator. Needless to say, minerals of high magnetic permeability are more readily separated and permit of easy adjustment. Minerals of low magnetic permeability require more careful adjustment and maximum field strengths. The proportion of magnetic material in the field has considerable influence upon the capacity of the separator. Where there is a small proportion, as, for example, 10%, the capacity of the separator is determined by the capacity of the feed belt. With proportions exceeding 50%, the capacity of the separator is determined by the capacity of the take-off belts. In the *Journal* of Sept. 16, 1918, p. 868, I discussed this subject at length.

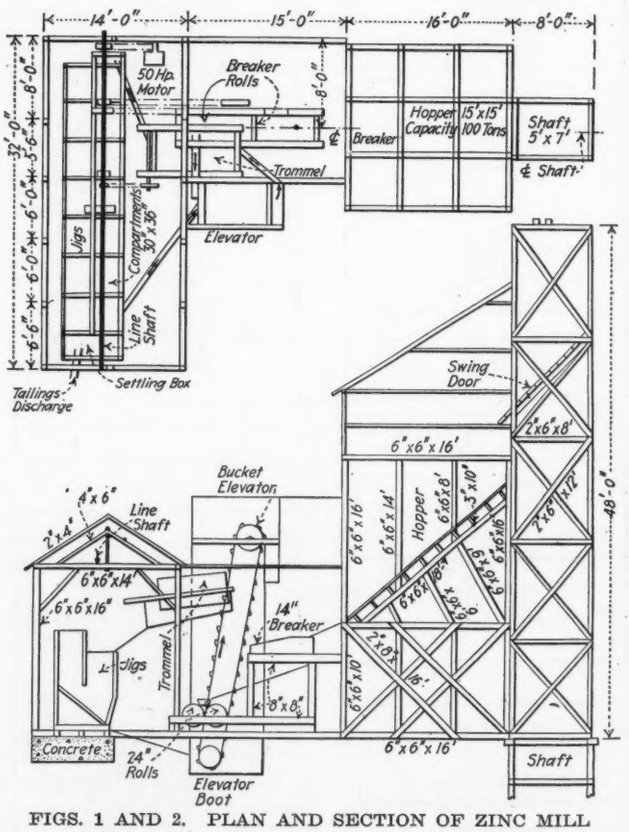
## The Design of a Small Zinc Mill

BY W. F. BOERICKE*

The plan and section of a small zinc mill, supposed to have a capacity of 75 to 100 tons per eight-hour shift, are illustrated by Figs. 1 and 2 of the accompanying drawings. The mill was erected during the boom period of 1916, in only six weeks' time, at the remarkably low cost of $7200. The principal objective at the time was to get the mill built and operating as soon as possible, to take advantage of the extraordinary prices for ore then prevailing. It ran successfully for six months, and made a satisfactory recovery from a comparatively thin feed of high-grade ore. That is to say, on heads running about 4.5% Zn the tailings averaged about 1.5% Zn, an estimated recovery of 66 per cent.

A glance at the flow sheet (Fig. 3) will show that the mill was of the simplest character, without a single unnecessary piece of machinery. Indeed, the design might be criticised as lacking some details that would have added considerably to the recovery. Though admitting this, the owners undoubtedly believed that the mill would do well enough for the purpose intended. If the mine developed sufficiently to justify a further capital outlay, it would be an easy matter to enlarge the mill. Much money is often lost by putting up equipment and buildings far more elaborate than the mine can afford or can supply with ore. When there is doubt as to the future of the orebody, and yet some immediate return is required, it is often necessary to compromise with efficiency for the time being.

In this particular case, only one mill elevator was needed in the entire milling process, whereas three or four elevators are required in the usual mill. On account of a natural slope of the ground, no tailings elevator was required. The disposal of the chats from the last cell by returning to the elevator with the oversize, and thence to the rolls and over the jigs, is the weakest point in the design. As there was only one elevator, however, this was necessary, in order to get them over the jigs again. An improvement would have been to run them through a small set of "chat rolls," thence to an elevator, and through a second trommel. The




FIGS. 1 AND 2. PLAN AND SECTION OF ZINC MILL

oversize should be returned to the rolls, the undersize going direct to a set of four sand jigs. This would prevent overcrowding the rougher jig, and thus secure better work.

One of the principal difficulties in a single-jig mill is that the jig is likely to be overcrowded, with attendant difficulty in adjusting the beds. Unless the jig-line shaft is split, the jigs will all operate at the same speed, although better results might be obtained by running the last cells at a different speed from the first. It is customary to run the rougher about 180 r.p.m., whereas the sand jigs may have a fast, light pulsion stroke, with little suction stroke, at a speed of 220 r.p.m. Such re-

Mining engineer, Galena, Ill.

finement is difficult to obtain when all the work must be done on a single jig. The practical result is that, in general, the tailings from the single-jig mill are higher in zinc than in the case of the two- or three-jig mill. But a great deal depends on the watchfulness and individual skill of the mill man, and his experience with that particular type of ore. Excellent work can be done with a small mill, with the right kind of ore and the right kind of men.

The amount of water required for a mill of this kind is about 500 gal. per min. A large proportion of this can be saved and re-used, by drawing it off from the settling box, and running to the mill pond, from which it can be pumped back to the mill. The amount needed from the mine, or an outside source, need not exceed 100 gal. per min. Where pure water can be obtained, however, it is better to use it, as there is less chance of contaminating the concentrates with limestone. Frequently the substitution of fresh water, instead of re-using the water, has cut down the lime in the concentrates more than 1 per cent.

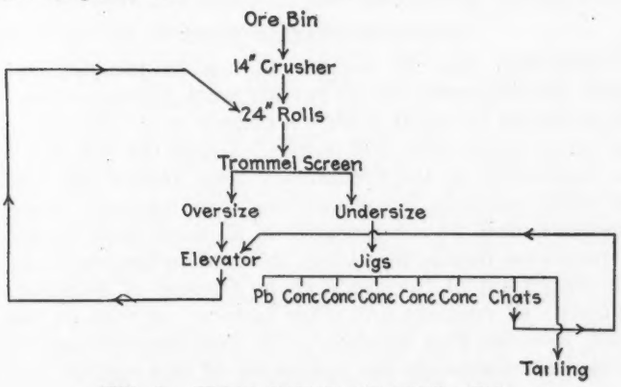



FIG. 3. FLOW SHEET OF ZINC MILL

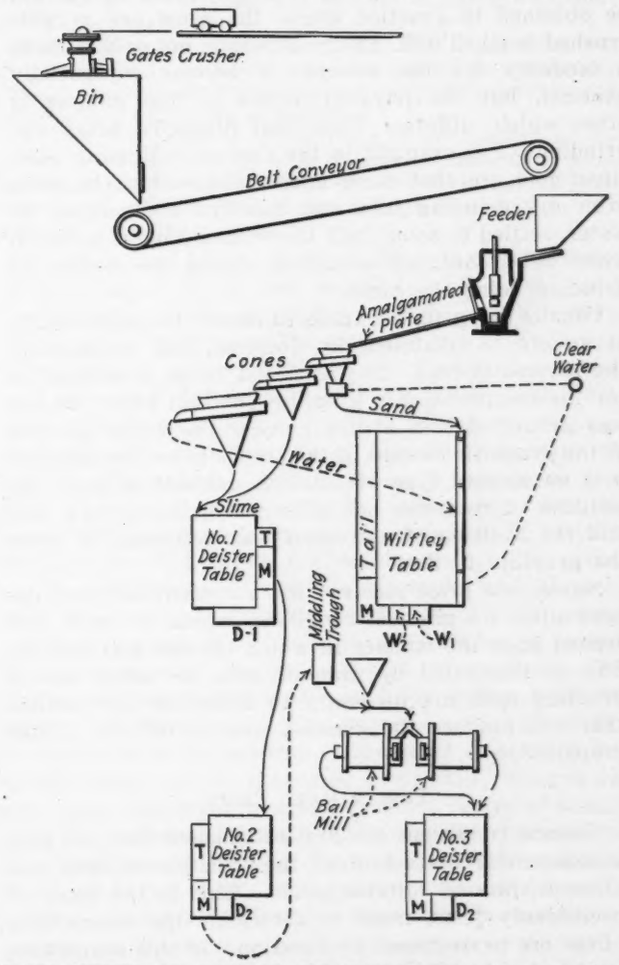
The small mill has considerable advantage over its larger prototype. It requires fewer parts, and consequently there is less danger of breakdowns and loss of time. Adjustments are simpler and more quickly made. Power and water consumption are smaller. It is generally more easily kept warm, an important consideration in a cold climate, where below-zero weather brings fresh troubles for the mill man. Depreciation charges are less, if this item be charged against the milling cost.

Labor costs are usually about the same as in a larger mill. The crew consists of a crusher-feeder, a mill man, and a helper, and the same crew can run a properly designed mill of three times the capacity. Hence the per-ton milling costs are much higher than in the operation of a big mill. The total amount of lumber required for the mill plans shown was about 20,500 board feet. A 50 hp. motor was used.

## Homestake Tungsten Mill

The tungsten mill of the Homestake Mining Co. has a battery of five stamps, which are electrically driven and crush from 15 to 25 tons per day. The screen is 22 by 12 mesh, steel wire, with openings 0.02 by 0.056 in. An amalgamated plate, 4 ft. 6 in. wide by 4 ft. long, is used outside the mortar, and small pieces of copper plate are placed at suitable points on the tables and in launders, from which an appreciable amount of amalgam in collected. The tailings pass to one of the plate houses, and thence to the general classification and cyaniding systems of the large mill. The average gold content of the tailing is about the same as in the general run of Homestake ore. The arrangements of the tungsten mill are sufficiently elastic to allow of various combinations of units to suit different grades of ores, and are available for general testing purposes.

The ball mills are cast-iron barrels, 2 ft. diam., inside, by 2 ft. 6 in. long. The feed and discharge are through hollow trunnions, and chrome-steel balls are used. Two grades of concentrate are made on the Wilfley table, and one grade is made on the first Deister, and a fourth low-grade product on the two lower Deister machines. The concentrates are received in iron-lined boxes and dried by steam. Middlings collected from the lower Deisters are carried by hand to a V-shaped trough, whence a small stream of water conveys them to the feed box of the ball mills.




FLOW SHEET OF HOMESTAKE TUNGSTEN MILL. W, W, D, D INDICATE FOUR GRADES OF CONCENTRATE. T = TAILING. M = MIDDLING

The mill was started in June, 1916, and has since been operated continuously on an ore which has yielded an average of 2% $WO_3$ in the form of a concentrate averaging 54 per cent.

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North Butte's bonus system of paying miners is working satisfactorily, with increased efficiency shown. Development work on Edith May fissure continues in grade of ore above 4%. Development work on upper levels has put considerable tonnage of second-class ore in sight or indicated. Crosscutting continues at Sarsfield shaft, with no change.

# An Outline for Flotation Test Work

By H. L. HAZEN

IN PREPARING an ore for flotation tests the sample is crushed, as nearly as possible, by the method to to be used in the prospective mill. The value of an entire investigation may be seriously impaired by failure to observe this condition. The results of preferential flotation tests made on ore dry-ground in a disk grinder would be no criterion of those that would be obtained in practice where the same ore is wet-crushed in a ball mill. In dry grinding, not only is there a tendency for the mineral to become superficially oxidized, but the physical nature of the gangue is often widely different from that displayed after wet grinding. For example, in the case of a Mexican lead-silver-gold ore that came under observation the pulp, after dry grinding in a disk machine and pulping in water, settled to about half the volume that it occupied when wet-ground, all conditions except the method of grinding being the same.

Usually dry grinding tends to impair the amenability of an ore to treatment by flotation, but occasionally the reverse is true. It was found in an investigation for the treatment of a graphite ore that after the ore was ground dry in a disk grinder the major portion of the graphitic content of the ore could be concentrated in a mechanical type of flotation machine without the addition of reagents, but after wet grinding in a ball mill the addition of a reagent was necessary to cause the graphite to float.

Again, the price received for a concentrate may depend upon its physical condition, which, in turn, will depend upon the manner in which the ore was ground. This is illustrated by graphite ores on which special grinding tests are necessary to determine the method that will produce the greatest amount of No. 1 flake graphite.

## Preliminary Tests

General conditions are first established that will give a commercial extraction of the valuable mineral and a concentrate of suitable grade. This is the stage of preliminary tests, made to determine the amenability of the ore to treatment by flotation. In this connection, is it not only necessary to discover the reagents that will give the best extraction, but the general flow sheet for the prospective treatment of the ore must be determined. If the desired extraction can be obtained by direct flotation, this would be the most desirable method, as it gives a simple flow sheet and low operating costs, and it would hardly be expedient to carry the investigation, at this stage, past the selection of the proper reagents.

Should direct flotation fail to give a satisfactory extraction, the value of auxiliary methods that might aid flotation in giving the desired result should be investigated. By way of illustration a few of the actual examples that have come under observation are given: With some complex copper-zinc ores carrying a large amount of pyrite it was found necessary to make first a bulk flotation concentrate and then roast the concentrate and re-float it before a commercial separation of the copper and zinc minerals could be obtained (Horwood's process). In making tests with another base-metal ore no mineral whatever could be extracted until the sands and slimes were separated. A certain volcanic mud carrying oxidized copper, after sulphidizing, required a dilution of ten to one for flotation. With many oxidized ores and a few unoxidized ones table concentration proved to be a helpful auxiliary to flotation.

The reason for placing emphasis on extraction in the preliminary tests is to minimize the work as much as possible and therefore the cost of the investigation. For example, if it were later found that some reagent other than those reagents established at the time of testing would materially increase the extraction, all work subsequent to these tests would have to be repeated so that conclusions might be drawn from tests made with the new reagent.

## Locked Flotation Tests

Assuming that the results obtained in the preliminary flotation tests justify further work, all subsequent experiments are made in such a manner as to reproduce, as nearly as possible, mill results. Should the flow sheet as established in the preliminary tests require the use of other methods in conjunction with flotation, these methods must be incorporated in all tests made to determine the details that affect the returns derived from the treatment of the ore, such as fineness of grinding, quantity of reagents and other factors. In view of the fact, however, that flotation is the metallurgical method under consideration, the remainder of this outline concerns itself only with that phase of the treatment.

The middling product in flotation always contains gangue, occasionally mineral not entirely crushed free from gangue, and valuable mineral that yields to flotation only slightly, a portion of each of which in practice would enter the tailing product when the middling is returned to be treated with the incoming ore. The tailing product from a single flotation test never represents the character, and not always does it determine the assay value, of that product as obtained in continuous operation.

For the purpose of obtaining in the laboratory a representative flotation tailing product, a locked test is made on a number of equal portions of a crushed sample of the ore. The middling product from the concentration of the first portion is added to the second portion, the middling product from the treatment of this combination is added to the third, and so on until the desired number of portions have been treated. In this manner the gangue, and perhaps some mineral, in the middling product is given an opportunity of entering the tailing, and a stage of equilibrium is soon reached in which the tailing receives as much gangue or mineral from the middling product of the preceding run as it in turn gives up to the new middling product. Once this stage is reached, the tailing product will closely represent that obtained in practice.

It is occasionally found that the assay value of the successive tailing products of a locked test will increase steadily up to the point of equilibrium, and this maximum assay value will represent the assay that will be obtained in the prospective mill unless some method is

found to render the mineral more amenable to treatment by flotation. Equilibrium is usually reached at the end of three or four circuits, but a locked test of five circuits gives a desirable factor of safety.

### Fineness of Grinding

A sample of the ore is crushed to pass 40 mesh, and a screen analysis, with assays, is made on a portion of the crushed material. Five other portions from the same lot of ore are successively concentrated, forming a locked test as already discribed, and a screen analysis, with assays, is made on the fifth flotation tailing product. The percentage extraction from each screen size is calculated from the weight and assay of the respective sizes as obtained in the two screen analyses, and the coarsest size to which the ore should be ground in practice so as to give the greatest commercial return is determined from a consideration of the extractions and the cost of grinding. For the purpose of determining accurately the critical crushing point, another sample of the original ore is ground to pass a screen one size coarser than the economic size determined by the first test, and the entire test is repeated.

It has generally been found that for mechanical reasons 40 mesh is about the coarsest material that can be efficiently handled in a flotation machine, and the ore need be ground no coarser than that for the first of the foregoing tests. With many ores this one test will determine the critical crushing point with a close approximation to accuracy, and the second test may sometimes be neglected if other data on corroborating tests are at hand. In the majority of cases, however, the test on more finely ground ore should be made, because the increased comminution will liberate a greater quantity of colloidal material, which will have a decided effect both upon the character of the froth and the amount of reagents necessary and therefore may affect the extraction from the different sizes of crushed ore.

Besides this, when dealing with gold and silver ores in which the gold and silver is intimately associated with two or more base-metal sulphides, the extraction from the various sizes as determined with ore crushed to pass a 40-mesh screen may not be the same as if the ore were crushed to a finer mesh. The reason is found in the different hardness and flotative qualities of the base-metal sulphides. As an example, a larger percentage of the galena than of the sphalerite contained in an ore will, on crushing, enter the finer sizes, and as the lead sulphide is usually more easily floated than the zinc sulphide, a better extraction of the associated precious metals might be obtained from the finer sizes with coarsely crushed ore than if the ore were more finely comminuted. The second test, made on finer ore, will eliminate any error due to either the presence of more colloids or a difference in the hardness and amenability to flotation of the constituent materials.

The method so often used of crushing samples of the original ore to pass various mesh screens, and concentrating each sample separately, will not indicate the critical crushing point with accuracy. In the first place, when an ore is crushed in the laboratory to pass a certain mesh, the number of particles of any given size will vary greatly from that resulting from crushing on the milling scale to pass the same mesh screen. The several reasons for this follow:

1. The degree of comminution of an ore crushed in the laboratory to pass a given mesh varies inversely as the frequency of screenings made during the grinding. It depends upon the personal inclination of the investigator, for instance, whether an ore crushed to pass 80 mesh contains 20% to 50% plus 200-mesh material in the final product.

2. Almost universally the mill depends for classification upon the rapidity with which the particles of the ground ore settle through water, whereas in the laboratory the classification is made with screens. With the exception of flaky mineral, such as molybdenite, graphite, and mica, the main factor controlling the size of the constituent minerals in the final mill product is their specific gravity, and the heavier minerals will be more finely crushed than the lighter ones. In the laboratory, specific gravity plays no part whatever in determining the fineness of the ground ore; size is the only factor.

3. A mill working in closed circuit with a classifier will receive in the oversize return a large amount of ore already ground to the desired fineness and which by regrinding is comminuted more than is necessary.

4. The first crushing that a lump of ore receives on entering a ball or pebble mill produces immediately some material of the requisite fineness, which is ground still finer as it proceeds through the mill, thus tending to produce an overground product.

In the second place, when crushing various samples of the original ore to pass different sized screens, and concentrating each sample separately, slight assay errors could easily cause the economic crushing point to be incorrectly determined. As an illustration, take a gold ore crushed to pass a 60-mesh screen with 10% plus 80 mesh, on which, by re-grinding the 10% to pass 80 mesh, 50c. more per ton of plus 80-mesh material can be obtained. A test made on a sample of the original ore crushed to pass 80 mesh would result in a tailing product assaying only 5c. less than if the ore had been crushed to pass a 60-mesh screen. Five cents per ton could be easily lost in assay errors and 60 mesh reported as critical grinding point instead of 80 mesh.

The ore, crushed to the economic fineness, is tested to determine the smallest amount of reagents, the minimum time of treatment, and the lowest ratio of dilution required to give the extraction. It is difficult to determine in the laboratory the exact amount of reagents which will be consumed in practice, because in continuous operation the usual constant return of water from the tailing, carrying soluble reagents, will generally result in a rather lower consumption of the reagents than used in test work. This, however, gives the investigator a feeling of security in reporting the maximum quantity of reagents necessary in practice as the minimum quantity found to be sufficient in the test work. A large amount of test work could be done to determine the minimum quantity of reagents, but this can more readily be done in the mill. From the time of treatment and pulp dilution, the size of flotation machine can be determined.

### Corroborating Test

A locked flotation test is made under the conditions established as giving the greatest profit from the treatment of the ore. This is the last test of the investigation and is made to substantiate the conclusions drawn from the preceding tests. The type of flotation machine to be recommended for use in the prospective mill should be used in this test, as, other conditions being constant, the extraction is often affected by the type of flotation machine employed. All the products of the test are assayed, and they should closely parallel mill results.

# Ammonia Leaching of Copper Ores*

BY LAWRENCE EDDY

DURING 1918 a number of improvements, mostly of a mechanical nature, were made at the plant of the Kennecott Copper Corporation, at Kennecott, Alaska. The leaching plant at Kennecott is designed to treat the tailings from a wet concentrating mill, and has handled up to 450 tons per 24 hours. The maximum capacity, however, with the equipment to be described, is over 600 tons per day.

The ore contains copper in the form of sulphides, mostly chalcocite, with some covellite, and also oxidized copper in the form of the carbonate, malachite. The gangue is limestone. There is no native copper present. Treatment of the ore on concentrating jigs and tables gives a good recovery of the heavy sulphides, but the malachite is inclined to be porous and flaky, and is of nearly the same specific gravity as the limestone; hence 40% of the copper in this material passes into the tailings. The ordinary acid leach is not suitable to recover this copper, because it also attacks the limestone. Flotation would entail more grinding, and sulphidizing.

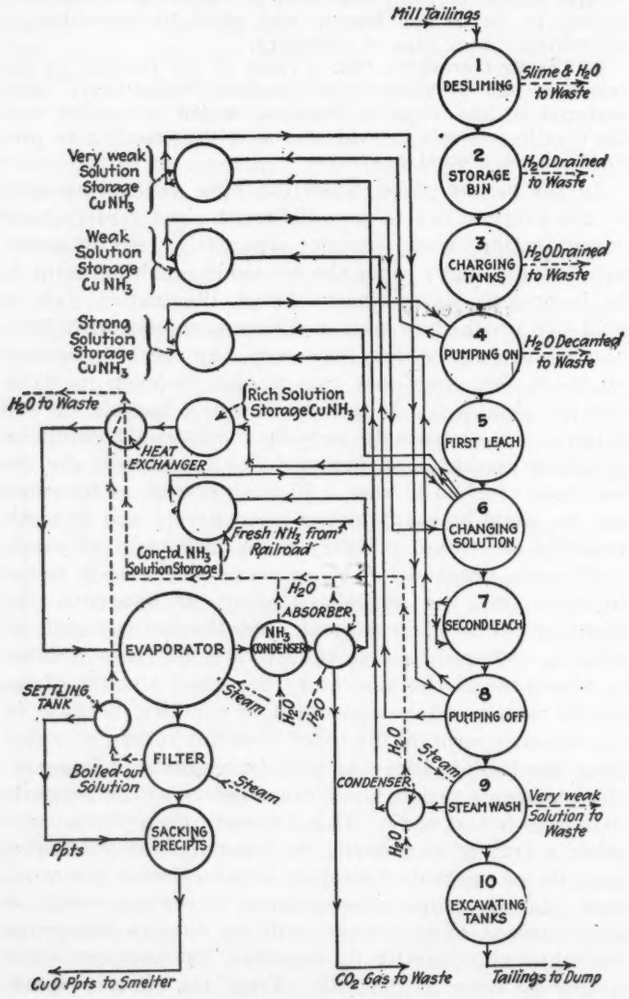


FIG. 1. FLOW DIAGRAM

Under these circumstances ammonia leaching was adopted, and the process has now been cheapened so as to permit its application to a wide range of ores. Ammonia will not recover gold or silver, or any copper sulphides, unless roasting is resorted to. With oxidized copper having the general form $CuCO_3 \cdot Cu(OH)_2$, a dark-blue solution is formed which on heating gives off $NH_3$ vapor, $CO_2$ gas, and deposits a heavy black powder consisting mostly of CuO. I am not prepared to give the chemical formula of the blue copper-ammonia solution. I believe that it is a mixture of cuprous and cupric combinations; also that the proportions differ under different conditions. Table I shows the character of the mill tailings as they reach the leaching plant. Copper sulphides are also present, in addition to the oxidized minerals, to the extent of 0.20%, but being inactive in the leach they are considered as part of the gangue. Roasting would not pay, because of the small quantity of sulphides which would be recovered.

TABLE I. SCREEN TEST OF MILL TAILINGS

| Size | Per Cent. Weight | Per Cent. Copper in Oxidized Mineral | Percentage of Distribution of Copper in Oxidized Mineral |
|---|---|---|---|
| + 12 mm. | 5.6 | 0.69 | 3.8 |
| + 9 mm. | 17.0 | 0.71 | 12.0 |
| + 6 mm. | 24.5 | 0.75 | 18.3 |
| + 2 mm. | 27.6 | 0.79 | 21.7 |
| + 1 mm. | 5.6 | 0.90 | 5.0 |
| + 40 mesh | 4.1 | 1.20 | 4.9 |
| + 60 mesh | 1.9 | 1.43 | 2.7 |
| +100 mesh | 2.7 | 1.41 | 3.8 |
| +150 mesh | 1.3 | 1.20 | 1.6 |
| +200 mesh | 1.5 | 1.45 | 2.2 |
| —200 mesh | 8.2 | 2.94 | 24.0 |
| | 100.0 | | 100.0 |

TABLE II. SCREEN TEST ON LEACHING PLANT HEADS

| Size | Per Cent. Weight | Per Cent. Copper in Oxidized Mineral | Percentage Distribution of Copper in Oxidized Mineral |
|---|---|---|---|
| + 12 mm. | 6.0 | 0.69 | 4.7 |
| + 9 mm. | 18.1 | 0.71 | 14.7 |
| + 6 mm. | 26.1 | 0.75 | 22.4 |
| + 2 mm. | 29.4 | 0.79 | 26.5 |
| + 1 mm. | 6.0 | 0.90 | 6.2 |
| + 40 mesh | 4.4 | 1.20 | 6.0 |
| + 60 mesh | 2.0 | 1.43 | 3.3 |
| +100 mesh | 2.9 | 1.41 | 4.7 |
| +150 mesh | 1.4 | 1.20 | 1.9 |
| +200 mesh | 1.6 | 1.45 | 2.6 |
| —200 mesh | 2.1 | 2.94 | 7.0 |
| | 100.0 | | 100.0 |

TABLE III. SCREEN TEST OF LEACHING PLANT TAILINGS

| Size | Per Cent. Weight | Per Cent. Copper in Oxidized Mineral | Percentage Distribution of Copper in Oxidized Mineral |
|---|---|---|---|
| + 12 mm. | 6.0 | 0.21 | 6.1 |
| + 9 mm. | 18.1 | 0.18 | 15.7 |
| + 6 mm. | 26.1 | 0.18 | 22.7 |
| + 2 mm. | 29.4 | 0.19 | 26.9 |
| + 1 mm. | 6.0 | 0.19 | 5.5 |
| + 40 mesh | 4.4 | 0.25 | 5.3 |
| + 60 mesh | 2.0 | 0.28 | 2.7 |
| +100 mesh | 2.9 | 0.28 | 3.9 |
| +150 mesh | 1.4 | 0.29 | 1.8 |
| +200 mesh | 1.6 | 0.32 | 2.5 |
| —200 mesh | 2.1 | 0.68 | 6.9 |
| | 100.0 | | 100.0 |

## BRIEF COMMENT ON FLOW DIAGRAM

Item 1. The mill tailings are leached as they come from the jigs and tables without any further crushing. They must be deslimed, however, because the slimes have the bad effect of cementing the ore in the leaching tanks, forming a hard mass that is penetrated with difficulty by the leaching solution or the steam wash. It is also much harder to excavate the leached tailings unless they are cleaned of material finer than 200 mesh.

*Abstracted from *Chemical and Metallurgical Engineering*, Vol. 20, No. 7, p. 328.

Desliming apparatus consists of two Esperanza classifiers 5 ft. wide and 30 ft. long. One only is in use at a time, the other being a spare. Table I shows the character of the deslimed ore. Most of the minus 200-mesh material has been removed, but all the fine sands are left in the ore. At present these slimes are run to waste, pending further development as to their treatment. An extraction of 80% can be obtained from the deslimed ore. Screen tests show that the best results are obtained with finer sizes, plus 60-mesh material giving the best extraction. However, the extraction from the coarser sizes does not drop enough to warrant putting in a crushing plant, which, if in operation, would cause a still greater slime loss.

Item 2. A 300-ton storage bin is installed to permit of short shutdowns in either mill or leaching plant without inconvenience.

Item 3. The ore is fed from bin gate to an elevator by a 32-in. apron feeder. It is elevated to the top of leaching tanks and conveyed by a chain scraper to the charging doors on the tops of the leaching tanks, into which it drops by gravity. The resulting cone of ore is leveled off inside the tanks by revolving the excavator mechanism backward, and by hand shoveling. The rate of charging the tanks is about 600 tons per 24 hours.

Item 4. It is to be understood that processes 4 to 10 are applied to the ore without transferring it from one tank to another. The order in which each step of the process occurs is from top to bottom of the chart. There are eight steel leaching tanks, constructed as shown in Fig. 2, which are charged and used in rotation. Process 4 requires about eight hours, during which the lixiviant is pumped into the bottom of the tank and rises up through the material. This displaces the moisture contained in the ore, which is approximately 5% of the dry weight. Part of this can be decanted off the top of the charge and run to waste as it rises above the incoming ammonia solution, but part becomes mixed with ammonia and is decanted into the weak-solution tank. The remainder is left in contact with the ore, where it dilutes the leaching solution.

Item 5. The ammonia solution is allowed to stand on the ore for 12 hours, without agitation.

Item 6. A portion of the first leaching solution, approximately saturated with copper, is pumped from the bottom of the leaching tank. At the same time an equal volume of concentrated ammonia, together with some weak copper-ammonia solution, is pumped on the top of the charge.

Item 7. For 30 hours the leaching solution is circulated through the charge by a centrifugal pump, which draws the solution from the bottom and discharges it on the top of the charge.

Item 8. Having dissolved all the copper that will go into solution in 30 hours, the leach is now drawn off from the bottom of the charge and transferred to the storage tank for strong copper-ammonia solution; at the same time 20 or 30 tons of weak solution or wash is pumped to the top of the charge and allowed to trickle down through it, so as to wash out the strong leaching solution.

Item 9. Steam is turned into the top of the tank for about 12 hours, so that it heats the entire charge. This vaporizes any ammonia left in the ore, the weak ammonia vapor passing out of the tank through the drain pipes in the bottom and being recovered in a special condenser, from which it is transferred to the weak-solution storage tank. When the ammonia content of this condensate has fallen to 0.45%, the wash is considered finished and the steam is turned off.

Item 10. The doors in the bottom of the tank are opened, and the tailings discharge to a conveyor belt and are transferred to the tailings dump. Less than half the charge runs out by gravity; the rest is excavated by means of a number of scrapers that revolve about a central shaft and are lowered in the tank by means of an automatic feed screw. Some of the tanks are not yet equipped with this excavating mechanism, and in them a light "slip scraper" is used. This is guided by hand and pulled by a small hoisting cable working through the top door of the tank. This device is unsatisfactory, because a great deal of time and valuable cooling water must be expended before a man can get into the tank to guide the slip. Formerly all tanks were excavated by hand shoveling at a cost of about 11c. per ton.

## The Leaching Tanks

Fig. 2 is a sectional view of one of the leaching tanks, of which there are eight. The incoming ore was formerly distributed over the tank by means of a rotary feeder, to prevent segregation of the finer particles. Recently this has been found unnecessary, and now the

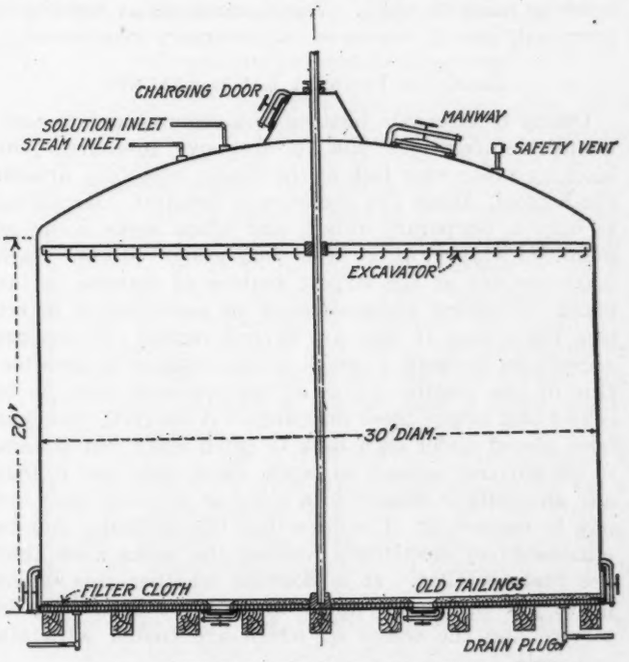


FIG. 2. SECTIONAL VIEW OF LEACHING TANK

ore is simply dumped into the tank through one of the top doors and leveled off. This method of charging gives a light porous bed of ore, which is easily penetrated by the solutions. It is advisable to level off each charge carefully, so that identical volumes of leaching solution will always just submerge the ore. Otherwise costly irregularities in the operation of the plant will ensue, and the storage tanks will be taxed by a large amount of idle solution.

While the tank is being charged, and during the interval between charging and the application of the first leaching solution, a considerable quantity of water seeps out of the ore and is allowed to escape by unscrewing drain plugs in the bottom of the tank. If this water were left in the ore it would dilute the leaching solution,

and eventually would have to be boiled out of the system in the evaporators at a considerable expense for steam. Therefore this drainage is important, and should be encouraged as much as possible by hurrying other processes to allow a maximum interval for drainage. Plugs are used, because no valve or cock has been found that will remain tight more than a few weeks. Where lines run from one tank to another a little leakage through the valve will cause no loss of solution, and an ordinary all-iron gate valve is perfectly satisfactory, but all pipe ends that lead from the system must be protected by plugs.

The tanks are made of single-lap riveted steel plate, about $\frac{5}{16}$ in. thick. It is well to construct the dome top with a short radius, so as to furnish added strength against suction. Occasionally during the steam wash, a vacuum results, due to too rapid condensation of the steam, and this may buckle a weak top. The same thing occurs when a careless operator pumps solution out of the tank without opening a relief valve on top of the tank. In opposite effect, too much steam may cause the flat bottom to bulge and leak badly at about 5-lb. gage pressure. All these difficulties can be obviated by a good safety valve, set for small differences both of pressure and vacuum. Such a device, made entirely of iron, has not been found on the market and must be made to order. Vapor pressures as mentioned previously are all measured by a mercury manometer.

### Leaks in Tanks a Large Expense

Owing to alternate heating and cooling, and to accidental deformations due to excessive pressures, the leaching tanks soon leak at the seams, especially around the bottom, where the pressure is greatest. Recalking is only a temporary relief, and often leaks occur at points of support or at other inaccessible places. Such leaks are one of the largest sources of expense in the plant. Constant vigilance must be exercised to detect new leaks, and, if they are beyond remedy, to arrange receptacles to catch as much of the solution as possible. One of the routine duties of the operator must be to collect and empty these drippings. A concrete floor has been placed under each tank to catch leaks, but it fails in its purpose because so much water gets into it that any ammonia is diluted to a point at which it does not pay to recover it. I believe that this difficulty can be eliminated by electrically welding the tanks when they are first installed. It is doubted whether this would prove practicable on tanks which have been long in service and the seams of which are coated with silt and scale.

Gage glasses on leaching tanks are unnecessary. If used, they must have all-iron fittings, which are expensive and hard to get. One should guard against running up the cost of installation with such accessories, which may be convenient, but not indispensable.

### Construction of the Filters

The entire bottom of the leaching tank is covered with a filter bed adapted from cyanide practice. One thickness of heavy duck makes a satisfactory filter and can be purchased already sewed and cut to fit the tank. To protect this cloth from mechanical wear a cover of "coco matting" is placed over it. Both cloth and cover are cut 6 to 10 in. larger than the bottom of the tank, and this flap is calked into a recess left between the tank wall and the wooden grid which supports the cloth. A piece of manila rope calked into the trough holds the cloth firmly in place, and as an added precaution strips of wood are nailed around the circumference on top of the filter and its cover. The grid to support the cloth can be made of fir strips 2 in. high and 1 in. wide, nailed together so as to leave a 1-in. space between each two strips. They must be notched on the under side to permit free drainage of the filtrate along the bottom of the tank to the outlets. They should not be fastened with metal clips or strips, because these soon disintegrate in the leaching solution, and lodge in valve seats, pump impellers, and other places. After from 18 to 24 months' service the grid becomes soft and pulpy and must be replaced. The life of a filter can be greatly extended by always leaving 6 in. of tailings on top of it when excavating the tank. Under such circumstances filter cloths and covers ought to last 12 months. This natural filter bed must be changed every few months when it becomes saturated with slime. This bed forms a dead space in the tank that will not impart any copper to the leaching solution which occupies it; hence the first few tons of solution drawn off the tank after the first leaching period will be low in copper, and should be run into the weak-solution tank to avoid diluting the main part of the rich solution.

### Doors, Piping, and Pumps

All doors and frames are of cast steel, with finished surfaces where necessary. They can be shut on a gasket by means of a screw clamp. The most satisfactory and cheap gasket for everyday use on 12 by 12-in. and 12 by 16-in. doors consists of several thicknesses of building paper, well smeared with some sticky substance such as paint—cold-water paint is good. This gasket can be used but once. Sheet rubber packing makes a better but much more expensive gasket that can be used several times. Asbestos sheet and woven packing is yet more expensive but no better. Cotton wicking is always kept for emergencies. Improperly packed doors in the bottom of the tank cannot be readjusted after the tank is full, but their leaks can be mitigated by calking with a bit of wicking around the outside.

Under some conditions the ammonia solution has a chemical action on iron. A hot solution containing a little copper will corrode the iron walls of a pipe to such an extent that the pipe is eaten entirely away at the threaded connection after a few months, and must be renewed. Metallic copper is left behind, and presumably the iron goes off as a hydroxide. After more than two years of continual service, the leaching tanks, however, do not show evidence of such action. It is thought that the solution has to be in rapid motion, as when flowing through a pipe, in order to promote corrosion.

It is possible to transfer all ammonia solutions needed in this process with six pumps. There are also a number of pumps required to handle cooling water for the condensers, water for use in excavating the leaching tanks, and other uses determined by the local conditions. It is good practice to have not more than two sizes of pumps, of standard make and construction. This means that all-iron ammonia pumps will be used on ordinary water service, but the saving in the initial outlay for spare parts alone will cover the additional cost of the pump. When it comes to piping, a great saving in the money tied up in the warehouse can be effected by installing not more than two different sizes of pipe. For

all ordinary work 2-in. piping is ample, both for suction and discharge. By arranging the pumps on interconnected headers, as shown in Fig. 3, it is possible at times to allow two suction lines to discharge into the same pump, so as to give ample capacity.

The most satisfactory small-size pump which has been tried out is a centrifugal pump, direct connected to an electric motor. Such a pump, with a 5-hp. motor and inclosed-type impeller, will deliver 125 gal. per min. against a 50-ft. head. The inclosed impeller is more efficient than the open type, but must be carefully watched, and bits of wood and ore that lodge there removed, as these cut down the capacity of the pump and of the whole plant. Before installing a pump it should be carefully inspected, because manufacturers of all-iron pumps obstinately insist on fitting them out with such parts as brass petcocks and screws, which must all be taken off before the pump is used.

Small reciprocating steam pumps are troublesome to pack and oil, in comparison with centrifugals, and are not economical unless their exhaust can be utilized. There is an excess of waste heat about a leaching plant

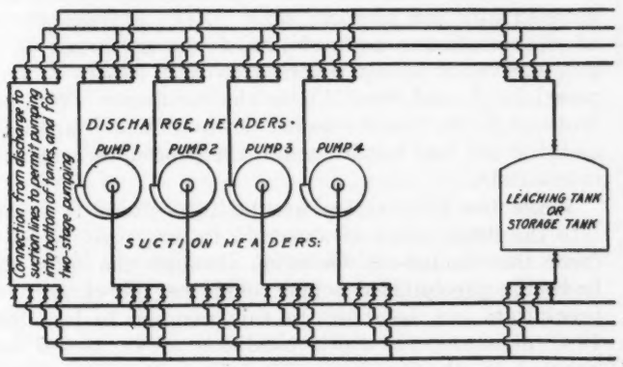
Connection from discharge to suction lines to permit pumping into bottom of tanks, and for two-stage pumping
DISCHARGE HEADERS
PUMP 1
PUMP 2
PUMP 3
PUMP 4
SUCTION HEADERS
LEACHING TANK OR STORAGE TANK

FIG. 3. PIPE AND PUMP DIAGRAM

as it is, so that, ordinarily, no use can be found for any such exhaust steam.

Air lifts, where the compressed air comes in contact with the solution, are not favored, because a certain amount of ammonia would be carried off with the exhaust air in the form of vapor. A steam injector might prove feasible for the purpose of charging the rich solution into the evaporators, where the heating of the solution would be a desirable feature. An all-iron injector for this purpose has been under consideration for some time. At present the evaporators are charged by a 4-in. centrifugal pump, which is a standard type at the Kennecott plant.

### Filtrate From Evaporators Hard To Handle

The most difficult solution to handle is the filtrate from the evaporators, or "boiled-out solution," as it is called. It is hot and contains enough dissolved copper to act strongly on the iron valves and piping. Valve wedges and stems will be out of operation after only a few weeks' service. Copper oxide also is present, which has leaked through the filter cloths and is carried along in suspension. This acts like emery dust, quickly cutting the shaft and other surfaces of a pump. The most satisfactory method of handling this material has been to apply steam pressure to the filtering tanks, so as to force the liquid through the filter cloth and out to the settling tanks.

Operating a centrifugal pump is something of a fine art at best, and with ammonia solutions new symptoms develop which a novice would fail to diagnose. For instance, in pumping strong ammonia solution, the reduction of pressure in the suction pipe causes some ammonia to vaporize and spoil the priming of the pump. By placing an ammeter on the pump motor it is possible to detect many troubles, as the instrument shows whether a gland is too tight, or so loose as to let air suck into the pump (a common trouble), and detects a plugged pipe line or a valve accidentally left closed. By suitable connections one ammeter on the switchboard can be connected to any pump motor at will.

It is a great help in breaking in new operators to paint the various solution lines with distinctive colors. Solution pipes should never be buried, but should be left out in the open for easy inspection and repair. Pipes and valves carrying hot solution must be frequently replaced, so a lavish use of unions is good economy.

As for valves, standard all-iron "clip" gate valves are satisfactory, although they cannot be relied upon to seat absolutely tight after a little wear. Plug cocks may be used, but in the 2-in. size are hard to manipulate. Special ammonia valves and fittings, such as refrigerating plants use, are absolutely unnecessary and are expensive. A permanent pipe-fitter's bench, fitted out with vise, cutters, taps, dies, and similar conveniences, is an essential part of the plant.

### Function of the Evaporators

The evaporator has a twofold purpose: first, to remove the dissolved copper from the system at the rate it enters into solution from the ore, so as to maintain the dissolved copper in a state of equilibrium; and, second, to remove water as fast as it is introduced from the moisture in the ore and from the steam that enters the system, so as to maintain the volume of solution nearly constant at all times. From the standpoint of economy it is important to minimize the quantity of water entering, so as to save steam in the evaporators; in other words, it is better to evaporate a small quantity of solution, rich in copper, than a large quantity of weak solution.

Fig. 4 shows one of the duplicate units evolved for use after expensive large-scale experiments with various types of evaporators. Although it will no doubt be further modified from time to time, this is by far the most satisfactory type put in operation up to the present.

The great difficulty in evaporator construction and operation has been the hard scale of copper oxide that tends to form over the interior surfaces both of the evaporator itself and also of any steam coils or other heating surfaces. This renders the ordinary continuous distilling column, with its complicated passages and trays, absolutely useless after a few hours' operation. The higher the copper content, the greater the trouble. However, scale will not be deposited on vertical surfaces, or on steep surfaces making an angle of 40° or less with the vertical. The evaporators of Fig. 4 are free from all scale trouble and will run for months without cleaning. There are no heating surfaces to crust, because steam is admitted directly to the solution from a perforated pipe. It is also essential to admit a jet of steam to the tip of the cone to keep the precipitated copper agitated. If allowed to settle it forms a dead space that would remain saturated with ammonia, and

this ammonia would be lost when the precipitates are dumped into the filtering tank. Moreover, settled precipitates are likely to form a cake that will not readily pass through the discharge cock. It is sometimes necessary to start the discharge by means of a long poker worked through the vent in the top.

### Details of Operation

At the start of operation, both *A* and *B* are filled half full of rich copper-ammonia solution. In practice this will test 5% copper and 7.5% ammonia. Steam is then turned into *A* only, and the valves in the vapor line are set so that the resulting vapors will pass from *A* into the solution in *B*, and serve to heat *B*. The vapors from *B* are passed through the condenser, which reduces the ammonia and water to liquid form. This condensate, together with the non-condensible $CO_2$ gas, flows downward through the absorber or cooler, the gas bubbling through the liquid so as to scrub out all the ammonia. The liquid is then received in a storage tank and held ready for use again as a fresh leaching solution. The

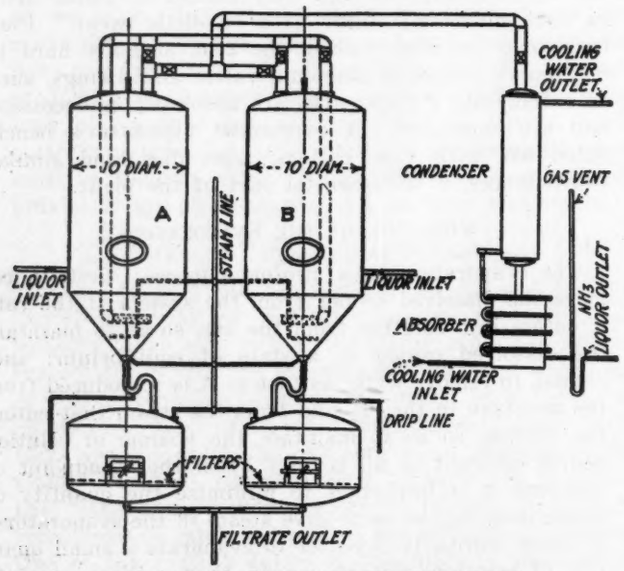


FIG. 4. DIAGRAM OF EVAPORATORS

$CO_2$ escapes through another scrubber, where it is washed with water or a weak ammonia solution.

As the solutions in *A* and *B* commence to become warm, the evolution of $CO_2$ becomes noticeable well before the boiling point is reached. No definite temperature can be set for this occurrence, because it depends on the composition of the solution, but usually the gas becomes noticeable at 130° F., and large volumes are given off before any ammonia vapor reaches the condenser. Between 160 and 170° F. and under a pressure of 2 to 5 lb. (gage) in the evaporators, the solutions begin to boil and evolve ammonia vapor. Soon after the ammonia starts, the evolution of $CO_2$ dies down and practically ceases. From this point to the end the evaporators show a bad foaming tendency; hence they are filled only half full at the start, and great caution is observed when admitting the steam. A practiced operator, however, will easily control his evaporators so that only an occasional trace of copper solution will pass over into the condenser. The first ammonia vapors to go over into the condenser are, of course, strong, but as the boiling continues they gradually become weaker, until at the end of the run they may be only 1 or 2% ammonia, the rest being water. The average ammonia content of the condensate from a complete run will be about 16 per cent.

After five or six hours' boiling the ammonia content of the solution in *A* will have fallen to less than 5%, and at this point copper begins to precipitate. It first comes down as a green copper carbonate, and would stay in this form unless steps were taken to prevent it. By raising the pressure in the evaporator to over 10 lb. (gage), and by keeping the precipitates agitated with the jet of steam in the tip of the cone, the carbonate is changed to the black copper oxide. This latter is a more desirable shipping product, because it will contain more than 75% copper, as against 60% for the green carbonate. However, if the market should develop, a good grade of copper carbonate could be produced.

Steam is kept on *A* until all but a trace of the copper has been precipitated and the ammonia content of the solution has been reduced to 0.03%. This should require 10 to 12 hours. At the same time the solution in *B* will have been reduced to about 2.5% ammonia, and the copper partly precipitated. Steam is now turned off *A*, the discharge cock opened, and the entire contents dumped into the filtering tank. Next a fresh charge of rich solution is pumped into *A*, steam turned on *B*, and the vapor valves reversed so that vapors from *B* pass into *A*, and from *A* into the condenser. The contents of *B* can now be boiled down to 0.03% ammonia and dumped into its filter, and the procedure continued indefinitely.

While the evaporators are boiling, steam is turned into the filter tanks at about 15 lb. pressure, so as to force the "boiled-out" solution through the filter and leave the precipitated copper oxide on the cloth. The precipitate can be dried in this manner to less than 18% moisture, in which condition it is sacked and shipped to the smelter. The filters consist of two layers of 8- to 10-oz. duck, protected by one cover of "hop cloth" and supported by a perforated metal screen. The cloths must be renewed about every four weeks, and the screens every four months. The filtrate should be passed through a series of settling tanks to save the small quantities of precipitate that always go through the cloth, together with the occasional large amount due to defective filters. The filtrate may also be passed over scrap iron, which will precipitate a small amount of cement copper from the last traces left in solution. If this is done, care must be taken not to allow the cement copper to cool while under the solution, because if it does the trace of ammonia present will redissolve it.

The discharge cocks on the evaporators are 4-in. all-iron abestos-packed plug cocks, with easily replaceable packing. Every week the plug should be taken out, polished, well oiled, and a new packing inserted. Even with this care, at times the cocks will leak and allow rich solution to escape from the evaporators. However, such leakage may be trapped and saved, as shown in Fig. 4.

The condensers are fitted with 2-in. boiler tubes of charcoal iron 12 ft. long, which must be renewed about every eight months. At least 65 gal. per min. of cooling water must be available for each condenser, although this quantity may not be needed all the time.

The services of one chemist are employed on routine analysis of solutions and experimental work. Analyses of the ore are made in the regular assay office by the mine assayer.

The following simple method of testing solutions for copper and ammonia was worked out by E. B. Hunn, plant chemist: Ten c.c. of solution to be tested is titrated against a standard cyanide solution until it is colorless; the amount of cyanide used indicates the percentage of copper in the solution. Another 10 c.c. is titrated against a standard $H_2SO_4$ solution, using methyl orange indicator. The acid reacts with both copper and ammonia until the solution is neutralized, at which end point it takes on a pale green color. From the quantity of acid used, and from the previously determined copper content of the solution, a specially prepared chart enables one to find the percentage of ammonia in the solution. These are the only determinations ordinarily needed to control the plant.

It is part of the operator's duties to sample every batch of solution which is pumped. He takes the sample from the discharge side of the pump through a special cock into a sample bottle, labels it and leaves it in a rack for the chemist. There is often a wide variation in ammonia and copper content in standing solutions at different depths in the same tank. On this account it is necessary to take the sample in several equal parts uniformly spaced over the entire time of pumping. The operator also keeps a daily log sheet, on which are entered the time, quantity, and disposition of every batch of solution pumped. Once daily he reads the gage glasses on every storage tank and enters this in the log sheet. Most of these storage tanks are 16 ft. in diameter by 20 ft. high, and the scale is calibrated to read in tons of 2000 lb. of solution. This unusual unit of liquid measure is convenient as to size, and saves a great deal of work when figuring in connection with quantities of ore, which of course are expressed in tons[1].

It is to be noted that all measurements, and the titrations for copper and ammonia, are really volumetric, and are accurate measures of weight only when the solution has a specific gravity of unity. This is seldom the case in practice, various solutions ranging from 1.06 to 0.97 gravity, so that for special purposes these differences must be taken into account.

## Costs

The leaching expense amounts to $1 per ton of ore treated, but the figure is misleading. Conditions in Alaska are unusual. There is no standard method of keeping mining costs, and the cost of treatment is greater for rich ore than for lean ore. Therefore the following example has been worked out, using the same quantities of labor, steam and ammonia which have been found necessary at Kennecott, but changing the rates to conform with usual conditions elsewhere.

It should be especially noted that the figures refer to leaching expense only. No charges are included for overhead expenses, mining and crushing the ore, tailings disposal, freight to smeltery and smelting charges, or selling expense. Little if any profit could be shown in leaching such a lean ore if all these charges had to be borne by the leaching plant. But in the case of treating tailings from a primary concentrator, as at Kennecott, it is proper to charge mining, crushing, and tailings disposal to the main plant, which would have to bear this expense if the tailings were not treated. Under these circumstances it is possible to show a profit with very lean ores. It should be noted that ammonia and steam expense, which are the two largest items, vary not only in proportion to the tonnage of ore treated but also in proportion to the copper extracted. Hence it is not so expensive to treat lean ores. Power, maintenance, and supplies will vary as the tonnage, whereas labor is constant and not affected by either tonnage or production.

Construction expenses vary a great deal according to local conditions. In the light of past experience, and under normal conditions, it is thought that $300 per ton of ore-treating capacity per day would be a reasonable estimate of the first cost of a small plant as described. One item that must not be overlooked is the initial supply of ammonia. About 275,000 lb. of 26° aqua ammonia or equivalent must be accumulated, and this may cost more than $30,000. Unless skill and foresight are used in manipulating the plant operations, peak demands for ammonia will at times call for a much greater supply. The foreman must aim to keep all the ammonia at work, for idle solution represents not only profitless investment, but calls for additional storage tanks, and results in unnecessary loss from leaks and evaporation.

EXPENSE OF LEACHING 450 TONS OF CRUSHED AND DESLIMED MILL TAILINGS PER 24 HOURS

Copper (oxidized) content of ore leached..... 0.85 per cent.
Copper (oxidized) content of ore tailings..... 0.17 per cent.

Gross extraction is 13.6 lb. copper per ton leached. Of this about 1 per cent., or 0.1 lb., must be deducted as dissolved copper lost in the leaching process, leaving 13.5 lb. per ton to ship to the smelter. This is shipped in the form of copper oxide containing 75 per cent. copper and 18 per cent. of total weight as moisture (percentage of copper figured on dry weight). Smeltery deductions will amount to 0.2 lb., so that the net copper sold will come to 13.3 lb. per ton leached, or 5985 lb. per day.

| Leaching Expense for | | | Total per Day | Per Ton | Per Lb. Cu Sold |
|---|---|---|---|---|---|
| Direct labor: | | | | | |
| 1 Foreman at | $6.00..... | $6 00 | | | |
| 1 Chemist | 5.00..... | 5.00 | | | |
| 3 Shift bosses | 4.50..... | 13.50 | | | |
| 3 Operators | 4.00..... | 12.00 | | | |
| 9 Laborers | 3.50..... | 31.50 | | | |
| 1 Repair man | 4.50..... | 4.50 | | | |
| Total..... | | $72.50 | $72.50 | $0.161 | $0.0121 |
| Power and lights: | | | | | |
| 630 kw. at 2.5c. per kw..... (1.4 kw. per ton) | | | 15.7 | . 35 | .0026 |
| Ammonia: | | | | | |
| 0.25 lb. per ton loss in leaching, lb.+ | | 0.25 | | | |
| 0.02 lb. per lb. Cu loss in evaporators. 13.5 × 0.02, lb.+..... | | .26 | | | |
| Total loss per ton..... | | 0.51 | | | |
| Cost, at $0.50 per lb. $NH_3$..... | | | 114.75 | .255 | .0192 |
| Steam: | | | | | |
| 94 lb. per ton for steam wash..... | | 94 | | | |
| 16 lb. per lb. Cu for evaporation 13.5 × 16..... | | 216 | | | |
| Total steam per ton..... | | 310 | | | |
| Cost at $0.001 per lb..... | | | 139.50 | .310 | .0234 |
| Maintenance and repairs: Includes cost of all maintenance of machinery and buildings, both materials and extra labor necessary..... | | | 25.00 | .055 | .0042 |
| Operating supplies: Sacks, oil and waste, packing, etc..... | | | 15.00 | .033 | .0025 |
| Total leaching expense..... | | | $382.50 | $0.849 | $0.0640 |

## Nipissing Mill Supplies

The consumption and cost of supplies at the low-grade mill of the Nipissing Mining Co. during 1918 were as follows:

| Material | Total Lb. | Cost per Lb. | Total Cost | Pounds Consumed per Ton | Cost per Ton |
|---|---|---|---|---|---|
| Sodium cyanide..... | 311,938 | $0.332 | $103,710.15 | 3.885 | $1.2913 |
| Caustic soda..... | 29,025 | 0.0694 | 2,016.00 | 0.361 | 0.0241 |
| Lime..... | 478,940 | 0.0063 | 3,040.39 | 5.966 | 0.0463 |
| Aluminum ingots.... | 3,750 | 0.521 | 1,953.25 | 0.046 | 0.0233 |
| Pebbles..... | 556,035 | 0.015 | 8,716.11 | 6.926 | 0.1075 |
| Coal..... | 2,157,790 | 0.0031 | 8,701.92 | 26.880 | 0.1074 |
| Borax..... | 7,391 | 0.123 | 910.86 | 0.092 | 0.0103 |
| Sodium sulphide..... | 54,701 | 0.0405 | 2,216.62 | 0.681 | 0.0266 |
| Power..... | ..... | ..... | 51,111.44 | ..... | 0.6357 |
| Oil (gal.)..... | 13.124 | 0.137 | 1,809.51 | 0.163 | 0.0215 |
| Coke..... | - | 0.006 | 239.38 | 0.451 | 0.0029 |

[1]We presume that fluid ton of 32 cubic feet is used—Editor.

# Industrial News from Washington

BY PAUL WOOTON, SPECIAL CORRESPONDENT

## House Committee Continues Hearing On Potash and Tungsten

As a result of the hearings which have been conducted by the Committee on Ways and Means of the House of Representatives, many are seeking the opportunity to present their views before that body. Letters received by the committee indicate that most of the American industries are in immediate need of a protective tariff or of higher rates of duty than are in effect. Though general tariff legislation at the extra session is not under consideration, the committee expects to take advantage of this period to conduct hearings and to get the point of view of all concerned in the industries most affected by foreign competition.

In considering the potash question, one of the points of contention has been whether the licensing system is preferable to the ordinary tariff. The respective conclusions in that connection are shown in the following colloquy between George Otis Smith, Director of the U. S. Geological Survey, and members of the committee:

Mr. Treadway: You speak of this licensing feature being intended to stimulate domestic production.

Mr. Smith: I should say the license system might be described as a necessary evil connected with stimulating production.

Mr. Treadway: Suppose we removed that so-called license system; what other suggestion would you have? In other words, if we did not establish the licensing feature, what other suggestion would you offer as a method of stimulating production?

Mr. Smith: If I knew of a method, I would be very glad to offer it. I do not see just how that can be accomplished, except through keeping the Government's finger, if you like, upon the individual wholesaler or manufacturer—simply seeing that he buys as much of the high-priced domestic product as he does of the low-priced—proportionately as much.

Mr. Treadway: Then Mr. Moore's suggestion of a possible tariff provision does not meet your view as to the best method of producing domestic stimulation?

Mr. Smith: There is this difference between the methods: It is contended, and I cannot pronounce on the logic of that contention, that the tariff on the imported article is added to the price of that article and therefore paid by the consumer. In this case, the price paid by the consumer would not be the price of the imported article; neither would it be the price of the domestic article. But it would be a weighted average of the two. The problem is simply to secure a market during this five-year period, which was fixed as the period of development of the industry. I think it [the licensing system] is a way of accomplishing what a tariff system might also accomplish.

Mr. Moore: Minus the revenue the Government might also get under a tariff system?

Mr. Smith: And I believe plus the advantage of a slightly lower price to the consumer. I might add that, looking at it from the national point of view, I believe the net expense of safeguarding the domestic production of potash would be exactly the same under the two systems—though the items would be differently distributed. The question becomes simply one of method preferred.

In reply to an inquiry as to the estimated output of potash in the United States for the current year, Dr. Smith said:

It is too early even to make an estimate on the subject, because there have been plants that have shut down, necessarily, and the best estimate that we can give is a capacity estimate at the beginning of this year, which we figure at approximately 100,000 tons.

A. G. White, the mining economist of the U. S. Bureau of Mines, however, does not agree that a tariff or a bounty is better than a licensing system. He said to the committee:

I believe the bill as presented is the best method of accomplishing the preservation of the potash industry. The principal reason for that belief is the fact that in endeavoring to start or maintain a new industry the best policy is to pay only for what you get; don't charge the country with anything that you don't get. Under this bill a higher price for potash is only maintained for the production you get. If you establish $2 or $2.50 as the price that you will pay for domestic material, you only pay it on the production that you get. If our estimates are wrong and we don't get production, it costs us nothing. We now have a capacity to supply about half of our tonnage requirements. That has been an accomplishment of the war. Many of these new plants which have developed have never had any advantage of the high prices during the war. There has been, so far as financial assistance is concerned, very little governmental assistance, if any, to the potash industry. The $50,000,000 bill was not turned over to the Interior Department. It originally rested in the hands of the President, but it was not turned over to the Interior Department until the date the armistice was signed. Not a dollar of that $50,000,000 fund has ever been used in any connection with the potash industry. The Government assistance to the potash industry consisted largely in the exploration of our potash resources.

Alsace produced about 4% of the total German output under German restrictive control. The capacity of the Alsace mines is much greater than 4% of the pre-war total. They are now producing twice their capacity before the war, and the Alsatian mines probably could produce four or five times in excess of their production before the war with the pumping out of a few mines and making a little new development, so that we have the two situations, the possibility of German potash, when the peace terms are signed, coming back into this country, and also the possibility of the development of a considerable French industry, which may also have, and has already had, its effect in this country. I understand that arrangements are being made to import French potash at the price quoted by dealers in New York, ranging from $1.50 to $1.75 per unit, which is somewhat over twice the pre-war price.

Frank L. Hess, the geologist of the U. S. Geological Survey who specializes in tungsten, in the course of his testimony before the committee, made the following statement with regard to tungsten:

I think there is no doubt that for the present, for the next two years, there cannot be much production in the United States under present conditions. There is now at least 4500 tons of ore in storage in New York, or close to New York—imported tungsten ores. I can only give you hearsay evidence on this—but it is the best I can get. One firm I know is said to have backed a buyer in Hongkong to the extent of $17.50 a unit on all of the tungsten ores he bought, and it has 1500 tons of that in New York now. Another firm has at least 1000 tons on which it paid at least as much—up to as much as $17.50 a unit. A third firm has backed a buyer to the extent of 1000 or 1500 tons up to $16.30 a unit. The first 1500 tons I spoke of is Chinese; and a part of the other is Chinese, but the larger part is

Bolivian and a little Argentina ore, I believe. That ore is going to hang like a pall over the market until it is gone. Now, if a tariff is put on that ore it will go at a price that will let those men out with a good profit. If a tariff is not put on, that ore is going to be held until those men find a favorable opportunity to let go or until they make up their minds they cannot make their money on it or until they conclude to swallow their dose and let go. That is one of the things that is going to hold back the production.

I believe, from all the information I can collect, that Chinese ore can be brought to this country for less than $7 a unit, but there are some peculiar circumstances that come in there that may keep it from coming in for a good while at that price. When the price was $25 and upward, before the armistice was signed, the steel companies sent men scurrying all over the world to buy tungsten ores. Of course, they went to China. The officials there—every man who got a chance at it—got a squeeze out of it—and those squeezes were all paid on the basis of $25—the price in New York City. Now, those officials are not going to let anybody get ore out now unless they pay something like that squeeze, and it is going to take a good while for them to make up their minds that such a price cannot be obtained.

Other pertinent statements made by Mr. Hess follow:

In the mines in this country, it is impossible to make any definite estimate or prophecy, except perhaps for the next year or two I think we might say we have in sight and we can produce 3000 tons for, say, three years. After that I should say it would be altogether a problem.

I might say conditions are changing all the time in the tungsten market. I do not think that the variation in the quantity produced and the quantity imported was due altogether to the discovery of the foreign field. The Australian field was discovered long before we began to be large importers. And I think you will find that our tungsten production and tungsten imports are closely connected with the rise and fall of the steel trade. You can almost surely take the use of tungsten as a barometer of the steel trade.

I think all that has been stated to you about the costs in the Colorado field is conservative. I do not believe they can produce profitably for less than between $17 and $20 per unit.

Roy C. McKenna, of the Vanadium Alloy Steel Co., another of the witnesses, said:

It is my contention that the market from April, 1916, to April 1917, dominated by American production, clearly proves that $17 a unit was the dead line for all except a very few American producers; and that a price of between $17 and $26 was needed to enable the fields, discovered during the boom period, to operate. In April, 1916, tungsten ore sold at between $75 and $85 a unit in New York. In May, 1916, the price dropped to a nominal quotation of $40 a unit. In September, 1916, tungsten ore could be freely purchased at prices around $17 a unit. The vast majority of all American tungsten properties ceased operating, or were operating only in part. In April, 1917, our company purchased 1100 tons, 550 tons domestic and 550 tons South American, at a price of $17 a unit f.o.b. Latrobe, Penn., and shortly afterward sold ferrotungsten for export to offset the quantity of tungsten ore purchased. From the summer of 1917, to the signing of the armistice in November, 1918, the market for tungsten ore was remarkably steady, around $25 a unit. Since November, 1918, the price of tungsten ore has steadily declined. This was due, to a large extent, to the discontinuing of certain taxes imposed on tungsten ore by Chinese Province officials, which, during the early part of 1918 was equivalent to from $4 to $6 a unit.

With the discontinuing of these unfair taxes, Chinese ore can be laid down in New York at under $7 a unit. The quality of Chinese ore is such that a premium of $2.50 to $3 a unit is paid for the best grade of South American and domestic ores.

The tariff that we have now does not any more than take care of the differential in wages between foreign countries and this country. There always was considerable high-speed steel imported into this country under any tariff act that we have had. The tariff of 15% ad valorem is needed in addition to the tariff which we would need to compensate us for the increased tariff on tungsten.

George H. Bailey, of the American Mining Congress, said:

The whole object of the proposed legislation is to stabilize the price of tungsten, which now has an extremely wide range of prices. The ad valorem tariff will work just the opposite effect. For example, a large foreign tonnage caused by opening an easily accessible mine or surface deposit would lower the price, lower the ad valorem tariff, and let the ore pour into the United States and destroy the industry here. With a scarcity of foreign ore, or in time of emergency, the demand would be abnormal, the prices would be greatly advanced, the ad valorem tariff would advance in the same proportion, and instead of reducing the fluctuation it would be actually extended. In short, the ad valorem tariff would increase the range of fluctuation in direct proportion to the percentage of the tariff.

Five thousand tons is Director Smith's estimate of the normal tungsten needs of this country. The estimate is made in the following statement:

The consumption before the war was in the neighborhood of 2000 tons a year. Last year it increased to something over 16,000 tons. I think that shows the stimulus given by war conditions, but that is not an estimate of what we may expect after the war. I think a conservative estimate is that 5000 tons would probably represent the normal consumptive needs of this country.

The import ratio of our consumption has increased somewhat during the war and, of course, was especially high last year, when by far the larger part of the tungsten consumed was imported. The question of supply, whether this country can be self-sufficient in the matter of tungsten for all time, I think can be answered in the affirmative. We have tungsten ore sufficient to meet our needs for many years, but there is reason to believe that the deposits would begin to decline in course of time, but, of course, we would expect to find some other deposits as yet unknown. However, it is a fact that under the war stimulus there was pretty active prospecting and new deposits were found.

## Board Will License Tin Imports

It was announced on June 16 by the War Trade Board that applications will now be considered for licenses to import pig tin and all metal alloys containing tin, including tin drosses, tin oxides, solder drosses, type metals, anti-friction metals, waste metals and other metals containing tin; subject, however, to the following conditions and limitations: (1) That such licenses will permit the importation only of shipments made from points of origin on or after June 30, 1919; and (2) that such import licenses will not be valid for entry until Aug. 1, 1919.

The duty recently imposed upon the exportation of certain lead ores was removed on May 31, 1919, according to a consular report. The ores affected by this decree are galena and litharge of all kinds, and all other non-silver-bearing lead ores. These ores are those included in Item 5 of the schedule of export duties, previously issued.

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All contracts entered into by the nitrate division of the War Department and the director of explosives have been liquidated. Sixty-one per cent. of the contracts made by the Chemical Warfare Service have been liquidated.

# Zinc Industry of Missouri, Arkansas, Kansas, and Oklahoma*

By OTTO RUHL†

YOUR secretary has asked me to bring up to date the subject presented last year—"Zinc Mining and Production in Missouri, Arkansas, Kansas, and Oklahoma." The chapter covering the last 10 months' mining operations in the Joplin-Miami district is but a repetition of the picture given you a year ago, with the exception that the lights have been fading, and the shades are deeper. To change the figure of speech somewhat, we then thought we were traveling over a rocky road in the darkness, and since then we have skinned our shins often on the rocks of high costs and waded deeper into the slough of lower receipts for our product, and are today praying with all our hearts that this is the darkest hour before dawn.

Hard hit last year, the zinc-mining industry of these four states is today in even a worse state than then. In Missouri one can count the active milling plants practically on the fingers of two hands. Arkansas has but a negligible output of zinc ore today. The two states of Oklahoma and Kansas are supplying the bulk of the output. Singularly enough, we find the efforts of the field to curtail its output only partly successful, a result due to the gradual but inevitable fruition of prospecting efforts begun two years ago. It has been said, and truthfully so, that 10 years' prospecting was accomplished in the Oklahoma field in two years' time. The results have been the development of a large number of mines whose output has been thrown upon the market and kept up the output of this district, in the face of untoward price conditions, to an unusual level. Much of this output is not the result of studied operation, but is incidental to prospecting and development, and in most cases is produced at a staggering loss. Yet the tonnage of these mines in the aggregate has maintained the output of the district at close to 10,000 tons per week.

It is difficult to reconcile this heavy production with the facts generally known as to prices for ores, and with the fact that so many mills are closed down. A census taken of the mills of the field within the last month showed that of 208 mills only 58 were operating, or approximately 28% of the potential producers. With the 58 operating, however, the bulk of the tried operators and the low-cost mills is found, a synonym for either high-class operation or extremely rich properties.

The following tables of shipments and prices for corresponding months of 1918 and 1919 show a consistent decline in prices received, but disclose no such decline in output:

COMPARATIVE PRODUCTION ALL GRADES ZINC ORE, 1918–1919

| Month | 1918, Tons | 1919, Tons |
|---|---|---|
| January | 32,995 | 27,102 |
| February | 22,250 | 40,228 |
| March | 47,955 | 50,851 |
| April | 45,810 | 36,899 |
| May | 44,315 | 47,579 |
| Total | 194,325 | 202,659 |
| Surplus on hand | 27,500 | 16,000 |
| Grand total | 221,825 | 218,659 |

COMPARATIVE ZINC ORE PRICES, 1918–1919

| Month | 1918 Per Ton Blende | 1918 Per Ton Calamine | 1919 Per Ton Blende | 1919 Per Ton Calamine |
|---|---|---|---|---|
| January | $57.02 | $32.67 | $43.44 | $35.01 |
| February | 55.00 | 33.00 | 41.78 | 26.27 |
| March | 50.14 | 34.73 | 41.54 | 27.74 |
| April | 42.03 | 32.93 | 38.87 | 26.61 |
| May | 47.79 | 31.00 | 37.80 | 24.80 |

Compared with 1918, the 1919 period shows an average reduction of $11.89 for blende ores and $3.06 for calamine ores. One would naturally assume that the reason for this condition must be explained by greatly reduced cost of operation. Though there have been some reductions in costs, they have not been commensurate with the reduction in prices received for the product. The reductions in cost have been approximately 10% in labor and a small reduction in hard iron and powder. Other costs either have been maintained or actually advanced, as in the case of power and lubricants. A reduction in one class of supplies is practically balanced by the advances in others. It therefore becomes increasingly apparent that much of the production being maintained is made at a loss. Recently, when the price of ore dropped to a $35.00 base, some of the strongest operators in the field shut down some of the best and richest properties, and weaker concerns and poorer properties can still be found desperately trying to keep going.

Under these conditions the production of the field is approximately 9000 to 10,000 tons, and its potential production, on a $45 to $55 market, can be readily determined at 50 to 60% more. From this situation it is evident that Joplin operators are hoping for a hurried revival of zinc consumption and a greatly increased use for this metal.

The end of the war brought with it the end of all price agreements and the coöperation between smelters and ore producers. The whole market situation reverted to the old open system where everyone was for himself and "the devil take the hindmost." The cooperative action between the sheet-zinc manufacturers and the high-grade zinc-ore producers, which was so satisfactory during the war period, today is almost forgotten history, and a similar movement to take care of all classes of ores, and with all the smelters, met a like fate before it was more than born. Certainly the industry needs such coöperation today as much as if not more than during the war period. But, so far as one can now see, the inevitable law of the survival of the fittest must take its course, and only those with unusually rich deposits can survive the squeezing process of high production costs and low ore prices. How long this process must continue to bring about the extermination of the output which will again balance local supply and demand is difficult to answer.

It was pointed out in last year's meeting that the souls of operators were born, kissed by the enthralling rapture of eternal optimism. The past year's history is confirming evidence that they will endure impossible conditions and yet live. If they cannot produce ore for a profit, they do it for philanthropy, and the world gets its zinc metal mined for less than cost.

*An address delivered at the meeting of the American Zinc Institute, St. Louis, Mo.

†Consulting mining engineer, Joplin, Mo.

The salient features of the year's history, as reflected in the zinc-mining industry of Missouri, Kansas, Oklahoma, and Arkansas, are: (1) That the production in Missouri and Arkansas has grown smaller since last year. (2) Output of Oklahoma and Kansas holds strongly at 9000 to 10,000 tons. (3) Production is maintained at a high level, in spite of large numbers of mills closed down. (4) Only the richest ore deposits can be worked and the best-organized companies operate, and much of the ore is being produced at a loss. (5) Ore prices declined $11.89 per ton over last year, but this did not greatly reduce output of ore. (6) Cost of production remains high, and changes in some items, though lower, have been balanced by others that have advanced. (7) End of the war brought all price agreements to an end, and no coöperative efforts since have been successful.

## Tariff on Metals for Canada

TORONTO CORRESPONDENCE

The changes in the Canadian tariff proposed by Sir Thomas White, Finance Minister, are expected to benefit materially the metal industry of British Columbia. The new tariff will give a protection of $20 per ton on lead, 1c. per lb. on zinc and spelter, and 1½c. per lb. on copper alloy, with an ad valorem duty of 15% on the semi-finished product. The difficulty in lead production hitherto was that the ore had to be sent to the United States for treatment. Under the proposed changes it will be profitable to treat in Canada lead ores which are largely refractory, the treatment of which was an expensive process. Several British Columbia mines which have been closed down are preparing to reopen, and are in the market for machinery.

## Concentration of Iron Ore at Mineville, New York

A decided change in the milling practice at the properties of Witherbee, Sherman & Co., at Mineville, N. Y., resulting in considerable improvement, has been made, according to a writer in the *Iron Trade Review* of June 12, 1919. With the aid of equipment which has been installed for re-treated tailings, the latter now contain on an average only 5 to 6% iron.

After each crushing, ore containing more than 60% iron is removed automatically, for transfer to stock bins, whereas tailings containing less than 5% of iron are rejected by the use of a magnet of lower tension. The ore is crushed first to a size which will pass through a 2-in. mesh screen. The 2-in. material, which remains after the 60 and higher per cent. ore is withdrawn, and after the tailings containing less than 5% ore are rejected, contains an average of 30 to 40% iron, the variation depending upon the grade of ore that is being worked. The ore then is re-crushed to a smaller size and the same process is performed again. In fact, the operation of withdrawing ore containing 60% or more of iron, and of rejecting tailings containing less than 5%, is repeated a number of times.

When the ore has been crushed to a size which will permit it to pass through a ¼-in. mesh screen, the re-crushing and separating are continued into much finer sizes, but from this point all tailings are thrown out which contain less than 6% iron. Therefore, the average metallic content of the tailings ranges from 5 to 6%. The average content of the concentrates is 64 and 65% iron, and this content may be increased or lowered by varying the intensity of the magnets employed in separating. At present, the purest material which is being turned out contains 71% iron, this being produced for special use.

After extensive experimenting, Witherbee, Sherman & Co. have developed a byproduct which for the last year has been manufactured successfully from the tailings from the Old Bed ore. The crude Old Bed ore has an average phosphorus content of 1.6%, and the tailings from this ore run 3% on the average. During the many years since the Old Bed originally was worked, there accumulated an enormous tailings pile, and investigations were undertaken with a view to utilizing the phosphorus content of these tailings for manufacturing fertilizer. This now is accomplished by milling the tailings to remove the iron obtainable from them.

By the use of tables of the Hooper, and Sutton, Steele & Steele pneumatic concentrating type, the gangue, which is composed mostly of silica and hornblende, is separated from the apatite. After the apatite crystals have been removed, they are mixed with barium sulphite, and the resulting product is a first-class fertilizer, called barium phosphate, which is sold to dealers.

## Exports of Mining Machinery

The exports of mining machinery from the United States during April, 1919, according to the figures of the Bureau of Foreign and Domestic Commerce, were as follows:

| Countries | Oil Well Machinery | All Other Mining Machinery |
|---|---|---|
| Belgium | ..... | $8,100 |
| France | $17,416 | 17,149 |
| Norway | ..... | 5,000 |
| Portugal | ..... | 668 |
| Spain | ..... | 4,348 |
| Sweden | ..... | 1,381 |
| Switzerland | ..... | 1,500 |
| England | 787 | 88,582 |
| Scotland | ..... | 68 |
| Canada | 14,627 | 66,730 |
| Costa Rica | ..... | 2,500 |
| Guatemala | ..... | 11,850 |
| Honduras | ..... | 1,721 |
| Nicaragua | ..... | 7,185 |
| Panama | ..... | 6,998 |
| Salvador | ..... | 3,324 |
| Mexico | 111,005 | 162,532 |
| Cuba | 19 | 11,171 |
| Dutch West Indies | 195 | ..... |
| Dominican Republic | 2,058 | ..... |
| Argentina | 37,923 | ..... |
| Bolivia | ..... | 49,808 |
| Brazil | 220 | 18,448 |
| Chile | 675 | 99,272 |
| Colombia | 2,107 | 1,045 |
| Ecuador | 7,176 | ..... |
| Paraguay | 190 | ..... |
| Peru | 5,424 | 17,185 |
| Venezuela | 14,050 | 500 |
| Japanese China | ..... | 2,043 |
| Chosen | ..... | 17,507 |
| British India | 22,969 | ..... |
| Dutch East Indies | 65,019 | 20,883 |
| Hong Kong | ..... | 250 |
| Japan | ..... | 7,631 |
| Persia | 1,954 | ..... |
| Australia | ..... | 16,296 |
| New Zealand | 29 | 210 |
| Philippine Islands | 16,133 | 2,173 |
| British South Africa | ..... | 136 |
| Portuguese Africa | 108 | ..... |
| Egypt | 535 | ..... |
| Totals | $310,619 | $654,194 |

**Regulation of Acidity of Flotation Pulp** at Anaconda is effected by the flotation operators, who maintain the pulp in the last spitzkasten of the flotation machines neutral to slightly acid to methyl orange. The tests are made hourly, or oftener if adjustments are being made.

## Domestic Graphite Sales in 1918

Domestic crystalline graphite sold during 1918 amounted to 10,564,080 lb. and was valued at $1,454,799, according to the U. S. Geological Survey. Production came from Alabama, New York, Pennsylvania, California, Montana, and Texas.

Amorphous graphite to the amount of 6560 tons, valued at $69,455, was sold from mines in Colorado, Nevada, and Rhode Island. The output of amorphous graphite in 1917 was 8301 short tons, valued at $73,481.

## Quicksilver in First Quarter of 1919

According to figures compiled by F. L. Ransome, about 5,960 flasks (75 lb.) of quicksilver was produced in the United States from Jan. 1 to Mar. 31, 1919. Returns from twenty-three productive mines gave a total of 5,924 flasks, and it is estimated that 36 flasks was obtained from two or three small mines in California and Oregon whose operators were not heard from. Of the 5,960 flasks produced, 4,023 flasks is credited to California, 1,698 flasks to Texas, 193 flasks to Oregon, and 46 flasks to Nevada. No production was reported from Idaho or Arizona. The quicksilver reported on hand at the mines or in transit to market at the end of the quarter amounted to 4,419 flasks.

As was expected, the output during the first quarter of 1919 was considerably less than that during the first quarter of 1918, which was 8,764 flasks. The unsold stocks at the end of the first quarter of 1918 amounted to 2,800 flasks, or 1,619 flasks less than at the end of the first quarter of 1919.

The falling off in production is the result of a combination of causes, chief among which were a lessened demand for the metal and a consequent downward trend of prices, the continued high cost of labor and supplies, and the curtailment of underground exploration and development during the war, when energy was directed chiefly to immediate production.

The price of quicksilver, compared with the prices that prevailed before the war, was still high at the end of the quarter, but not high enough to offset the general decrease in the tenor of the ore immediately available and the high cost of mining and treatment.

## Round Mountain Mining Co.

The Round Mountain Mining Co. is unique among mining companies in Nevada, in that a considerable part of its operations is in placer mining. Its lode operations are largely in the hands of lessees. In addition to the unfavorable operating conditions faced by all gold-mining companies during the recent period of higher costs, this company was handicapped by an inadequate water supply. The results of drilling operations for the purpose of prospecting the gravel banks ahead of the giants have been favorable, and the manager estimates that 600,000 yd. of material of a value of more than $1.00 per cu.yd. was sampled and proved in 1918. No dividends have been declared during the last three years, but about $150,000 of new assets, according to the last annual report, was added out of earnings.

During the year ending Dec. 31, 1918, a total of 71,367 cu.yd. of placer gravel was moved by hydraulicking, yielding 5299.84 oz. of bullion, having a value of $68,324.07. In addition to this amount, $2683.39 was received in royalties from the placer leases. The total operating cost was $48,792.38 and the total realization, $22,215.08. This operating cost does not include depreciation of pipe lines, main tailrace and placer equipment, but does include the cost of maintenance of pipe lines, sampling placer banks, and the development of branch races preparatory for 1919 operations. The gross value recovered, exclusive of placer-lease royalties, was 95.73c. per yd. The operating cost was 68.35c. per yd., or a realization of 27.38c. per yard.

During the year the production of the leases on bedrock in the Great Western "A" pit was $4586.66 from an area of 91,100 sq.ft. The gross yield was 5.03c. per sq.ft., of which amount 1.1c. per sq.ft. was paid to the company in the form of royalties. The cleaning of this area cost the lessees 5.1c. per square foot.

Drift leases on small areas west of the Gold Leaf cut were let during the year to determine definitely the values of the gravel overlying bedrock and to guide the company in future operation in this area; and 1450 tons removed by these bedrock lessees from an average width of 6 ft. of gravel yielded $6923.71, or $4.775 per ton, indicating a value per yard for this 6 ft. of bedrock material of $6.366. This area was found to be free from boulders and cemented gravel, and the drift-lease operations have proved a large additional yardage, of a value not looked for by the company, and no drift leases have been let since the above yardage values were determined.

In 1918, the company cleaned 45,500 sq.ft. of bedrock, yielding $9167.61, or 20.15c. per sq.ft. The average cost of cleaning this bedrock was 12.86c. per sq.ft. It will be noted that, of the total cost, development or the cutting and installation of branch races represents 5.9%, hydraulicking 72.8%, bedrock cleaning 12.2%, maintenance 4.6%, and sampling of placer banks 4.5%. Labor represents 77.2% of the total cost; administration and departmental costs were 10%, power was 2% and supplies were 10.8 per cent.

The final clean-up of the main tailrace was made in November, 1918, and yielded $10,045.11. Of this amount $6160 was obtained from the flume clean-up and $3885.11 recovered from milling 180 tons of concentrates from the lower end of the main tailrace, the concentrates showing a tonnage value of $21.58. This final clean-up represents 14.7% of the total gold recovered.

The production of the lode lessees of the Round Mountain Mining Co. for 1918 was 2131 tons of ore, having a value of $78,202.34, or $36.69 per ton. In addition, 20 tons of ore having a value of $627.05, or $31.35 per ton, was produced from the Blue Jacket group, held under lease by the Round Mountain Mining Co. The company received in the form of royalties from these operations $17,441.87, or $8.189 per ton, and in addition received as a royalty from the Blue Jacket lessees $64.36. Adding to this the amount received from losses for the use of the mill, there is total revenue from lode-lease operations of $19,657.24, equivalent to $9.14 per ton.

As an additional benefit to the company, the lessees performed 2292 ft. of development work as follows: 452 ft. of winzes, 643 ft. of raises, 238 ft. of crosscuts, and 959 ft. of drifts. Of this work 1313 ft. was done in the No. 1 workings, 127 ft. in the No. 2 workings, 323 ft. in the Stebbins Hill, and 529 ft. on the Saddle Back claim. In addition, 1033 ft. of working levels were retimbered and restored by the lessees.

## Twenty-seventh Engineers

The bronze medals that are to be given by the Association of the 27th Engineers to all former members of the regiment will be sent to them by first-class mail on July 1. Each envelope will contain the medal, a letter, and a mailing card for acknowledgment of the receipt. Each member of the regiment receiving the medal is earnestly requested to fill out the card, put a postage stamp on it, and mail it promptly.

The delay in sending the medals has been due largely to the time required in correcting the roster which has been used for the mailing list. In spite of all that has been done, there still remain 100 or more men for whom we lack correct address. It is therefore urged that every one who receives a medal and reads this notice will let former members of the regiment know that the medals have been sent, and if anyone fails to receive his medal before July 15, let him write to the undersigned.

It is important that every member of the regiment, in filling out the receipt card, or writing to the office on any other subject, state the letter of his former company.

The preparation of the history of the regiment is in hand, but it is likely to be a couple of months before it will be complete and mailed.

Since the disbandment of the regiment I have received letters from a good many of the men, perhaps 250 of them. With few exceptions they report the prompt return to their old employment or the finding of new jobs, and a general spirit of contentment seems to prevail. Men who are out of work or who have met with misfortune otherwise are singularly few, and this is of course a condition that calls for congratulations.

It has not been possible to reply personally to all of the letters containing messages that did not require specific answer, but the writers of them may know that Colonel Perry has looked through the file and has appreciated deeply the friendly remembrances of him that have been expressed.

We shall all be greatly obliged if mine managers will post this notice on their bulletin boards for the information of former members of the regiment who may now be in their employment, and who may not read the *Journal*.

W. R. INGALLS.

115 Broadway, New York.

## Miners Strike at Grass Valley

SPECIAL CORRESPONDENCE

Following the refusal of their demand for an increase in wages of 50c. per day, the entire underground night shift of the North Star Mines Co., at Grass Valley, Calif., consisting of 120 men, went on strike on June 13. The present scale is $4 per day for machine men and $3.50 for shovelers, with bonuses for extra work. Surface men were not consulted as to the proposed move. The day shift followed the night shift, and all underground work ceased. The strike then spread to the Empire mine, where the men quit in a body without consulting the management.

A mass meeting held on June 14 by the strikers was presided over by J. B. Bennetts. The situation was discussed and committees were appointed to present demands upon the management of the Pennsylvania, Allison Ranch, and Orleans, the first two being at Nevada City and the third being owned and operated by the North Star company. Employees of the Champion mine declined to join the strikers.

The burden of the strikers' arguments was that they could not support their families on present wages, some claiming that local merchants were charging 30% and more over Sacramento prices. The bonus system is said to have been unpopular as well. Surface men present were asked to join the strike, but refused. A strike pledge was signed and a relief fund discussed. Between 500 and 700 men are now idle (June 15).

The management of the North Star mines is reported to be insistent upon closing permanently rather than accede to the strikers' demand. It is stated that under present conditions the mine is just about holding its own. The small mines will be governed by the action of the larger ones. There are a number of gravel claims in operation throughout the county, but no effort has been made to include their operatives in the strike.

## Labor Situation at Cobalt

TORONTO CORRESPONDENCE

The miners at Cobalt, Ontario, at the instance of a representative of the Dominion Department of Labor, have agreed that they will not strike until Gideon D. Robertson, Minister of Labor, at present in the West, returns to Ottawa and uses his influence to effect a settlement. The attitude of the miners is stated to be favorable to conciliation.

The Cobalt union demanded recognition of the union; an eight-hour day, or 44-hour week, and in case of underground men the eight hours to be from collar to collar; and a wage scale of which the following is a summary:

Minimum base wage for all underground men, irrespective of the class of work, $4.50; men working in shafts and raises without helpers, $5.50, together with rubber boots and oilers; all surface labor, minimum, $4; blacksmiths, carpenters, and mechanics $5; hoist men, pump men, and pipefitters, $4.50; and in addition to the above a bonus of 25c. a shift with silver selling at 80c. and additional 25c. a shift for each 10c. above 80c. With the present price of silver this would mean a dollar a day bonus, in addition to the above scale. The union also asks time and a half for overtime and double time for Sundays and legal holidays, with not more than a dollar a day to be deducted for board. In case more than a dollar a day is charged, wages are to be raised the same amount. The scale calls for a minimum of $4.50 for underground men, but runners and helpers expect to be paid more than the muckers.

Though the managers do not object to dealing with committees of their own men, they are refusing to recognize the Western Federation. At present the operators are practically conceding a split between the eight hours face to face and the eight hours collar to collar.

Wages in Cobalt are higher than at any other camp in eastern Canada, and living conditions are among the best. Under the present price of silver, drill runners are making $5 a day; helpers $4.25 to $4.50; muckers $4 to $4.25; and surface labor $4 to $4.25. The proposed new scale would mean that several of the smaller properties and those which are nearing exhaustion would be unable to operate at a profit. In view of the high wages already being paid, it seems unlikely that these demands will be accepted.

# Editorials

## Progress in Milling

MILLING or wet concentration, and to some extent dry concentration, plays a most important part, and will continue to occupy its position, in American mining practice. From the day of the Gilpin County slow-speed, high-drop, inside-amalgamation mill, and the California stamp mill, there has been steady progress. The advance has been marked more by the greater perfection of mechanical devices than by radical changes in principle, although the introduction of hyposulphite leaching, the cyanide process, copper-ore leaching, zinc-ore leaching, and the flotation process must not be overlooked.

A review of the field shows that amalgamation of gold ores still occupies an important place, although the amalgamation of silver ores has disappeared. The hyposulphite leaching method has been completely discarded. The cyanide process still occupies an important place, although the flotation process threatens a part of its field. Leaching of certain types of oxidized copper ores is achieving increasing favor. The leaching of zinc ores has developed into considerable importance. Flotation has been adopted to a large extent, both as a primary and as a supplementary method of treatment, and wherever sulphide ores are handled this method deserves consideration.

The overshadowing importance of flotation is due principally to the fact that it affords a simple and effective method for the treatment of the more finely divided mineral particles which can be only indifferently saved by vanners, tables, and slime-concentration devices. By its use the recoveries from ores of copper have been increased from 60 to 80% up to 80 and 90%, and in some instances above the last-named figure.

The treatment of slimes long occupied the best efforts of ore dressers, and the invention of special tables, the perfection of the vanner, and the development of the round tables and buddles indicate the thorough way in which the mechanical methods were tried out. Despite these efforts, the treatment of slime and the more finely divided portion of mill pulps left much to be desired. The introduction of oil flotation held out vague hopes that this radical departure from mechanical methods would be more successful.

The slow development of the Elmore process through its various stages indicated a nearer approach to the solution of the problem. The final stages in the perfection of the flotation process were sudden, and its position was quickly attained. A quantitative appraisal of its present importance has yet to be made, nor have its manifold possibilities been exhausted. The least that can be said is that it has effectively removed the restrictions upon fine grinding, and has put recoveries obtained in concentrating mills upon almost an equal footing with those obtained by chemical methods of treatment.

The field of minor separatory methods, such as electromagnetism, electro-statism, and dry methods of separation, has broadened out, particularly in respect to the first two mentioned. Electro-magnetic separation now occupies an important place in the cleaning of iron-bearing zinc concentrates, tungsten concentrates, chromite, and rare earths. It demands consideration as a primary method for the treatment of magnetic iron ores. By the use of magnetizing roasting its field has been still further extended, and new applications may be expected.

Electrostatic separation is practiced to a limited extent in the cleaning of zinc concentrates, and has found application in the dressing of graphite ores. Dry concentration appliances have attracted some attention, although it is recognized that their field is limited and their use indicated only under special conditions.

Rapid progress in crushing and grinding, particularly in mechanical appliances, is a noteworthy feature in modern milling practice. The Blake rock crusher as a type has been greatly increased in size, and is still an important machine. Several different types of gyratories, each with important characteristics, are in use. The disk crusher competes with rolls for intermediate crushing. The cyanide process was responsible for the introduction of the tube mill, and the early ball mills were the forerunners of the short cylindrical ball mill now used as a fine grinder. Both the Huntington and Chilian mill have had to meet the competition of this modern fine grinder. Whether they will hold their own or not has yet to be decided. Stage crushing and grinding is a feature in many mills, although in many instances much simplified as compared with former practice.

In jigs and tables there has been little improvement. Both seem to be secure in their present position, the former for the prompt removal of coarse valuable minerals from the ore stream, the latter for the removal of grains of intermediate size. For ores characterized by coarse mineralization, jigging removes such a large proportion of the valuable mineral at a lower cost than could be done by other methods that there is no economic advantage in displacing it. The same may be said for the table. Further, there is no economic advantage in crushing any finer than sufficiently to liberate the recoverable proportion of valuable mineral.

Despite the temptation to simplify flow sheets by eliminating jigs and tables, and resorting to flotation as the sole means of separation, there is a well-marked tendency to adhere to stage concentration and to use flotation as a supplementary process for the treatment of the more finely divided material. This applies with greater significance to the ores wherein the minerals are in various-sized grains and aggregates irregularly distributed in the gangue, and less so with those ores in which the minerals are finely divided and disseminated throughout the gangue. With the latter type of ores the simplified flow sheet has important advantages which are becoming better appreciated.

Sizing screens, trommels, and classifiers present few new features. The increasing adoption of the ball mill in

closed circuit with classifiers has resulted in the use of a greater variety of the drag type of classifier. Spigot classifiers of well-known types, as well as hindered settling classifiers, dewaterers, slime and flotation concentrate thickeners, filters, and flotation concentrate driers, exhibit no noteworthy additions during the current year.

The latest event of critical importance in milling is the decision of the U. S. Supreme Court in the flotation patent issue. The result of this decision is to clarify and make definite the limitations of the Minerals Separation, Ltd., patent. Whether a mining company will find it more advantageous to use a flotation agent in excess of 1%, and thus avoid paying royalty, or to use a lower percentage and pay royalty, will be determined by laboratory experiments and comparative costs of the alternative methods.

## Rest Periods in Work

THE ever-growing demand for shorter working hours lends encouragement to any suggestion that will increase output. The National Industrial Conference Board, in its Research Report No. 13, publishes the results of introducing rest periods into the regular working hours of a large number of industries.

Experience has shown that in nearly all industries in which the manual work performed is a constant repetition of certain movements, or in which the brain work done varies but little from hour to hour, both body and mind become fatigued long before the workday is finished if an attempt is made to keep at the work continuously. It has been shown that, in nearly all of the plants cited in the report of the board, fatigue has been materially reduced and output noticeably increased through the introduction of short rest periods at proper intervals. These must not be at haphazard moments, but must be carefully regulated to conform to the temperament of the operative and the nature of the occupation; they may vary from one minute of rest in three of elapsed time to 20 minutes of rest after two hours of work.

The most notable achievement in increased efficiency, due to the introduction of rest periods, was obtained in connection with riveting work. In this occupation the best continuous records were made when a rest period was provided after the driving of every ten rivets; the total time allotted for this purpose aggregating 5 hours and 20 minutes out of a 10-hour day.

Around mining or metallurgical plants the work is generally so varied and so distributed in the time cycle that neither the brain nor the muscles become tired, hence little attention is given to any plan for rest periods. On the other hand, systematic rest periods might well be a subject for experimentation in such occupations as those of an ore-sorter, whose work consists of picking ore from a belt, or a hoisting engineer, who is directing the movement of a hoist that is running continuously.

The human system is such that if work is stopped for a few moments before actual fatigue has been reached, the system soon returns to normal vigor; but, once having become fatigued, a long rest spell is required to restore the original condition. The idea of rest periods is presented not from a sociological or humanitarian standpoint, but rather represents the instruction of an operative in a manner of working so that he may earn more with less effort. It is essentially an economic question.

## The Mexican Question

THE American public has shown a fine spirit in standing off and allowing the authorities at Washington to handle the Mexican problem as they saw fit. Despite occasional outbursts of feeling, and the impatience shown, there has been commendable coöperation, and the hope that in time Mexico might radically improve the existing conditions has been perennial. Of late a decided change is evident, and a feeling that something must be done to eliminate border disturbances and insure the safety of Americans in Mexico.

At no time has there been any justification for the absence of a firm governmental policy for the protec tion of Americans and their property rights. On the border, the Villa menace has been temporarily dispersed by the energetic drive of the U. S. Army. From the Mexican authorities comes the promise to save Americans from bandit attacks. On the prompt fulfillment of this agreement will depend subsequent events.

In Congress during the past week full investigation of all relations between the United States and the Republic of Mexico has been demanded by a resolution introduced in the House. On June 23, another resolution, directing the Secretary of War to send United States troops into Mexico to protect American lives and property there, was introduced.

The Mining and Metallurgical Society of America has submitted to its members, for formal adoption or rejection, the following resolutions:

Whereas their professional duties frequently call American mining engineers to Mexico; and,

Whereas the modern mining industry of Mexico has been mainly developed by American engineers; and,

Whereas many American mining engineers have suffered indignities, the loss of their property and even of their lives while traveling or sojourning in Mexico in the peaceful pursuit of their business; and,

Whereas such conditions have culminated in the murder at Teziutlan, on Apr. 16, 1919, of Edward L. Dufourcq, an able and highly esteemed mining engineer and a member of the Mining and Metallurgical Society of America; therefore be it

Resolved that the Mining and Metallurgical Society of America hereby protests to the Department of State in Washington against further disregard by the American Government of conditions in Mexico that make it unsafe for American engineers to go there in the practice of their profession and for the care of business interests intrusted to them; and be it further

Resolved that the Mining and Metallurgical Society of America urges the American Government to take prompt and effective steps toward the establishment of such law and order in Mexico as will safeguard the persons and property of our citizens and extend its protection to all Americans in any part of the world to which they may be called in the pursuit of their legitimate affairs.

Mining engineers, metallurgists, and mine operators are greatly interested in the Mexican situation, for many of them have suffered material injury by reason of conditions in Mexico. The action of the society is another example of the service that it has rendered to the mining industry.

Organized action is necessary, and particularly so in the present situation, as the signing of the armistice and the reported acceptance of the Peace Treaty by Germany have removed all excuse for further vacillation and delay on the part of the Federal Government.

## Illiteracy in the United States

A SALIENT and significant feature of the current reports of official Federal and state organizations, charged with the compilation of vital statistics, presented at a time when it is proposed to rearrange social and industrial relationships on a new basis having for its purpose the amelioration of many defects of the old, is the amazing percentage of illiterates in this country.

Eight and one-half million persons in the United States, over ten years of age, cannot read a newspaper, sign, or letter. Five and one-half millions of them cannot read anything in any language. These facts are brought to public notice in the report of the Department of the Interior, which has been compiled from several sources, including data on illiteracy in the drafted army, supplied by the Surgeon General's office. Further comparisons show that the illiterates and aliens of the country outnumber all the people in 15 states combined, and, as voters, would outweigh the influence of Greater New York, Philadelphia, and Chicago in national affairs.

This condition presents a problem which is national in scope. The South leads in illiterates, the North in non-English speaking population. Altogether, 10% of the adult population of the United States cannot read the constitution under which they live or the laws which they are presumed to know.

No particular study is necessary to create an appreciation of the economic waste involved in this deplorable condition, aside from other reasons for the correction of such an evil. Disregarding the cultural and social advantages of education, how can a man perform other than plain manual labor, or become but a poor substitute for machinery efficiently designed and operated, if he is unable to read or write?

Efficiency is becoming more and more essential in commercial competition. This country has witnessed the enactment of much radical legislation and governmental interference with individual preferences and habits of citizens, admitted to be necessary for obtaining efficiency, which is regarded as one of the most important national attributes. Certainly no other single factor can have as much influence on the final degree of national efficiency as the percentage of illiterates in the population.

The subject deserves the thoughtful attention of the leaders of every industry, and our lawmaking bodies should be brought to a realization of the importance of remedying the conditions responsible for the existing large percentage of illiterates in our population.

## BY THE WAY

F. W. Maclennan, the new general manager of the Miami Copper Co., may justly claim the distinction of being the first Arizona mine operator who used an airship to inspect the properties of his company. Mr. Maclennan accompanied Wilbur A. Wright in a flight over the Globe-Miami district on June 16, and is said to be enthusiastic over the possibilities of the flying machine and its worth to the manager of the future.

The following are extracts from an official publication of 1890, issued by a commission, bearing the stamp of authority of a great government, which includes in its pages an article on exploring for iron ore:

"Magnetite ores are frequently found with a large body of green and granite rock on the north and a body of quartzite on the south side. Frequently these may be a considerable distance from each other, but in the interval between them may be found a body of ore. These rocks when they come closer together form the walls of the vein enclosing the ore. Their distance apart can be calculated upon as a means to discover the depth of the deposit, it being generally considered that the point where they meet together underground will be the depth of the deposit. Frequently timber of fine growth in the iron formation indicates the presence of iron ore, as a good many mines have been found when the timber is straight and of good size, clear of underbrush, and of better quality in comparison with other trees of like kind in that vicinity. Where the timber is good and iron ore is found, it is generally first class but where the timber is of poor growth and a mixture of all kinds of scrubby wood, the ore as a rule is of inferior quality. Invariably very fine springs have been found where mines of a permanent character have been located. None of these are infallible signs, but all have their bearing on the subject, and attention to them will be rewarded with good results. Magnetic ores are generally found in beds. They are of all sizes, some containing a few tons, others enormous quantities.

"The writer gives it as his firm opinion, justified by facts, that no iron deposit surrounded on all sides by the same kind of rock will be lasting. Sometimes large outcrops on the surface have been found in these occurrences, but in every instance on practical working such deposits have been exhausted at short depths. It is deemed useless to spend money on iron-ore deposits unless they are found with the granite on one side, and then, between the granite and ore, diorite or green rock occurs, and on the other side of the ore quartzite or crystalline lime rock. The reader will perceive that this gives a distinct formation, which, experience goes to show, assures a permanency of deposit.

"The dipping to the north of an iron deposit is a very important feature in connection with its permanency. This northerly dip is caused by the abundance of ore in the mine, and its consequent attraction in that direction toward the North Pole. In some instances large deposits of ore occur dipping to the south near the surface, but at a further stage of development these dip to the north, which is a sure indication of a large body of ore.

"We may add that a large part of the mines now being worked in the Marquette district have been found at great depths. These discoveries were made through actual workings in a regular formation, although no trace of them was seen on the surface, showing that in working in a right formation large bodies of ore are constantly being found, although away from and apparently thrown off from the mine proper. This is accounted for by the ore coming in contact with an older formation of rock not showing on the surface.

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The Western office of the *Engineering and Mining Journal*, formerly in the Newhouse Building, Salt Lake City, Utah, has been transferred to the Rialto Building, San Francisco, California.

## Personals

**Horace V. Winchell** is expected to be in New York during the latter part of June.

**F. F. Sharpless** has left New York for Virginia on professional business.

**Amor F. Keene** has been elected a director of the South American Gold and Platinum Co.

**James MacNaughton,** first vice-president of the Calumet & Hecla, is in Boston on business.

**M. L. Requa** is the author of an article, "Technical Training," published in the June issue of "Sinclair's Magazine."

**Will E. Malm,** of The Malm-Wolf Co., examined mining property in Arizona recently.

**George A. Packard,** mining engineer and metallurgist, of Boston, Mass. has returned from Brazil.

**Franklin W. Smith,** is making a tour of the mining camps of Nevada and sections of California.

**J. P. Kerby,** representing a New York syndicate, recently visited the Rice Lake gold area, Manitoba.

**Arthur Notman,** superintendent, Copper Queen Mine, of Bisbee, is in New York accompanied by his family.

**A. J. Clark,** metallurgical engineer for Homestake Mining Company, at Lead, S. D., is in New York on business.

**Gerald Sherman,** consulting engineer for the Phelps Dodge Corporation, is visiting Philadelphia and other Eastern cities.

**Fred Walter McNair,** president of the Michigan College of Mines at Houghton, is in Washington on Government business.

**Edwin Reeder,** in charge of iron mining interests at Mexico, Ky., is in Houghton visiting relatives on his summer vacation.

**Ralph Ziesemer,** of the firm of Smith & Ziesemer, engineers, of Bisbee, Ariz., has returned from a business trip to California.

**Donald G. Campbell** will be engaged in exploration and development work for the coming year, near Lost River, Alaska, via Nome.

**Capt. Clinton Ball,** recently returned from overseas engineer service, has joined the faculty of the Michigan College of Mines.

**Oliver E. Jager** has been appointed metallurgist to the British America Nickel Corporation, Ltd., Nickelton, Ontario, Canada.

**J. B. Foster,** president, and **James P. Porteus,** superintendent of the Bonney mine at Lordsburg, N. M., will be in Chicago until July.

**J. Therseau,** of Minneapolis, representing oil operators of that city, is investigating the oil fields of the Peace River district, Alberta.

**Fred MacCoy** has resigned as mining engineer for the United Verde Copper Co. to accept the position of general manager of Negociacion Minera de San Rafael y Anexas, S. A., operating the San Rafael mine, in Pachuca.

**Fred Searls,** geologist and mining engineer, has returned to San Francisco after having served two years in France as an officer in an engineering corps.

**Julius Kruttschnitt, Jr.,** Arizona manager for American Smelting and Refining Co., with headquarters at Tucson, is visiting San Francisco and Los Angeles.

**E. A. Kronquist,** assistant geologist of M. A. Hanna & Co. is at Crystal Falls, Mich., engaged in geological research of the Michigan iron country for his company.

**Rush M. Hess,** consulting engineer for the Southern Manganese Corporation, has opened an office for general mining practice at 807 Brown-Marx Bldg., Birmingham, Ala.

**Charles E. Newton** has been appointed dean of the Oregon School of Mines, Corvallis, Oregon. Mr. Newton was formerly associate professor of metallurgy at that institution.

**J. A. Potter,** superintendent of the leaching plant of the New Cornelia Copper Co., at Ajo. Ariz., has returned home from an extended visit to the East, including a trip to Michigan.

**Edward S. Wiard** has resigned as consulting engineer for the Colorado Central Mines Co. and the Onondaga Mines Co., and will resume regular practice at 409 Boston Bldg., Denver, Colo.

**J. E. Spurr** has resigned as Executive of War-Minerals Investigations, Bureau of Mines, to take effect July 1. The War-Minerals Investigations work will be terminated on that date.

**Van. H. Manning** received the honorary degree of doctor of engineering at the commencement of the University of Pittsburgh on June 21, in special recognition of his activities in aiding the winning of the war.

**V. H. Hughes,** petroleum and mining geologist, announces that he has severed his connection with the firm of Valerius, McNutt & Hughes and has opened offices at 326 Mayo Bldg., Tulsa, Okla.

**P. D. McLaurin,** of Saskatchewan University, has been commissioned by the government of Alberta to investigate the possibilities of producing valuable by-products of the coal-mining industry.

**E. H. Sollards** has resigned as state geologist of Florida to join the bureau of Economic Geology of the University of Texas, at Austin. He is succeeded by **Herman Gunter,** previously assistant state geologist.

**B. O. Pickard,** district engineer for the U. S. Bureau of Mines, stationed at Houghton; A. E. Sporley, foreman miner, and Professor Sperr, of the Michigan College of Mines, attended the Lake Superior Safety Conference at Duluth.

**E. M. Shipp,** oil and mining engineer, representing the Lawrence C. Chamberlain Co., of New York, left New York for Texas on June 11 to make a survey of properties in which his company has become interested. Mr. Shipp expects to return on June 28.

**G. H. Clevenger** is now acting chairman of the Engineering Division of the National Research Council. The offices of the Engineering Division have been moved recently from Washington, D. C., to 16th floor, Engineering Societies Bldg., 29 W. 39th St., New York.

**A. A. Hassan** has been examining several prospective oil fields in Texas for the last six weeks and has decided to open an office in Fort Worth for the purpose of conducting a general business as oil geologist. His temporary address will be Westbrook Hotel, Fort Worth, Texas.

**H. E. T. Haultain,** professor of mining engineering, at Toronto University, on the occasion of his resignation as vocational officer in connection with the department of Soldiers' Civil Re-establishment, was presented with a McLaughlin touring car by 500 representatives of vocational training throughout Ontario.

**Harold P. Banks,** who served for 16 months during the war with the 2nd Division, A. E. F., in France and Germany, has been discharged from the service and will resume connections with the firm of John H. Banks & Son, 26 John St., New York. Mr. Banks was discharged with the rank of captain of field artillery.

**Arthur C. Terrill,** for the last four years head of the department of Mining Engineering at the University of Kansas, Lawrence, Kan., has resigned and accepted an appointment with the Kansas State Geological Survey. On July 1, he will move to Baxter Springs to take charge of lead and zinc investigations in southeast Kansas.

**James A. Farrell,** president of the United States Steel Corporation, has accepted an invitation to address the Pittsburgh Chamber of Commerce upon matters relating to America's participation in the field of foreign trade. Mr. Farrell is expected in Pittsburgh soon, and definite announcement of the date of his address will be made in the near future.

**Albin F. Victor,** the sales manager of the Lake Superior Loader Co., which is marketing the Armstrong underground shovel, recently returned from the service, where he was a captain in the 27th Engineers. Prior to his enlistment Mr. Victor was chief engineer for the American Manufacturing Co.'s. iron manganese mine on the Cuyuna Range in Minnesota.

**C. M. Eye,** superintendent for many years of the mines of the Benguet Consolidated Mining Co., at Baguio, Benguet, P. I., has resigned to return to the United States, where, after a vacation, he expects to be situated in or near San Francisco. He is leaving Manila on July 17, after which date his mail address will be San Francisco, care of Wells Fargo Nevada National Bank, until further notice.

**B. Britton Gottsberger,** general manager of the Miami Copper Co., has resigned his position with the company, to take effect June 15th. He is succeeded as general manager by **F. W. Maclennan,** formerly assistant manager. Mr. Gottsberger, who has had charge of the local management of the Miami Copper for a number of years, will take a long rest before again engaging in active mining operations.

**John M. Longyear,** of Marquette, has been reappointed, by Governor Sleeper of Michigan as member of the board of control of the Michigan College of Mines. **Ocha Potter,** of the managerial staff of the Calumet & Hecla, an alumnus of the Michigan College of Mines, has been named to succeed John W. Black, member of the board of management of the Ninth Federal Reserve bank board. Mr. Black recently moved to Minneapolis from Houghton.

**Judge E. H. Gary,** chairman of the United States Steel Corporation and president of the American Iron and Steel Institute, was recently honored by the trustees of the McKinley Memorial Building at Niles, Ohio, who have caused to be placed in the memorial a bronze bust of Judge Gary. The bronze is the work of J. Massey Rhind, New York sculptor. Busts of Roosevelt, Taft, H. C. Frick, and other statesmen and industrial leaders are also in the building.

**D. G. Kerr,** vice-president of the United States Steel Corporation, made his annual inspection of the mines operated by the corporation on the Minnesota ranges, during the week beginning June 16. He was accompanied by **W. J. Olcott,** president of the Oliver Iron Mining Co.; **Pentecost Mitchell,** vice-president; **John H. McLean,** general manager, and **J. H. Hearding,** assistant general manager. At the conclusion of their trip over the Mesabi and Vermillion ranges the party left to make an inspection of the mines on the Gogebic Range in northern Michigan.

**Col. G. A. Burrell,** president of the Island Refining Co., 62 Cedar St., New York, has been awarded the Distinguished Service Medal by the War Department for his work as chief of the research division of the Chemical Warfare Service. Colonel Burrell originated the Chemical Warfare Service in this country and had charge of a large research staff working on gas masks, poison gases, smoke screens, and signal lights. Wesleyan University, of Middleton, Conn., has given him the degree of doctor of science, and last year his alma mater, Ohio State University, gave to him the honorary degree of chemical engineer.

**W. A. Sloan** and **E. Leland** have taken over the assay and engineering office of Kempton & O'Neill in Nogales, Ariz., and will conduct a general engineering and assaying business under the firm name of Sloan & Leland. Mr. Leland for eight years was chief mining engineer for the Shannon Copper Co., Clifton, Ariz., and for the last year has been with the Phelps Dodge Corporation as chief geologist at that company's mine at Pilares de Nacozari, Sonora, Mexico. Mr. Sloan was formerly chief chemist for the Silver City Reduction Works, Silver City, N. M., and for the last ten years chief chemist for the Shannon Copper Co.

## Societies

**Society of Chemical Industry,** London, will hold the annual general meeting on July 15, 16, 17, and 18.

**The Institution of Mining Engineers** London, held the 71st general meeting on June 19. Among a number of papers presented were the following: "The Difficulties and Dangers of Mine Rescue Work on the Western Front" and "Mining Operations Carried Out by Men Wearing Rescue-Apparatus," by Lieut.-Col. D. Dale Logan, D.S.O. The 30th annual general meeting will be held at Birmingham on Sept. 10, 11, and 12.

## Industrial News

**Westinghouse, Church, Kerr & Co., Incorporated,** announce the election of Arthur King Wood, formerly president of the Franklin Trust Co., as vice-president and treasurer.

**H. Gardner,** No. 2 Metal Exchange Bldg., Leadenhall Ave., London, has taken out a license under the Non-Ferrous Metals Industry Act and will deal in metals. Cable address, Nonfermet, London.

**W. E. Caldwell Co.**, of Louisville, Ky., tank manufacturers, associated with J. B. Crawford, will build a cut-band sawmill in St. Landry Parish, Louisiana, where the company owns large tracts of cypress, ash, oak, and gum timber.

**The Edison Storage Battery Co.** announces the election of Maj Charles E. Sholes as vice-president, director, and general sales manager. Major Sholes succeeds Harrison G. Thompson, who has resigned to organize and conduct the Transportation Engineering Corporation of New York. Major Sholes has heretofore been identified with the construction, operation, and management of chemical industries and is familiar with the manufacture and consumption of heavy chemicals in the United States and Europe. During the war he served as a major in the Ordnance department, first as chief of the chemical branch and as Army representative before the War Industries Board. He was subsequently made contracting officer for the United States on the staff of Colonel La Mont and still retains his rank in the Reserve Corps.

## Trade Catalogs

**"Getting Results in Sheet Steel Work."** Solar Metal Products Co., Inc., Columbus, Ohio. Pamphlet; 8½ x 3¾; 8 pp.; illustrated. A description of fabrication of sheet steel between ten and twenty gages.

**Boss Cement Mixers.** The American Cement Machine Co., Keokuk, Iowa. Catalog No. P20; 8½ x 11; 8 pp. Illustrates 1920 type of Boss steel roller and pinion drive portable building mixers.

**Mine and Smeltery Structures.** El Paso Bridge and Iron Co., El Paso, Tex. Pamphlet; 4 x 9; 8 pp. illustrated. Containing photographs of prominent milling and smelting plants erected by the company in Arizona, New Mexico, and Texas.

**Boss Elevator Hoists.** The American Cement Co., Keokuk, Iowa. Catalog H20; 8½ x 11; 8 pp.; illustrated. Describes gasoline, kerosene, and electric hoists for use with single and double cage material elevators, derricks, spouting plants, drag lines, snatching wagons, excavating, and general construction.

**Standard Reinforced Spiral Pipe.** Standard Spiral Pipe Works, Chicago, Ill. Catalog No. 7; 7¾ x 10½; 40 pp.; illustrated. Descriptive of products of this company and method of manufacturing spiral pipe. Contains numerous illustrations of installations and complete price list for all sizes of pipe, fittings, valves, joints, and other accessories.

**Overhead Material Handling Machinery.** Sprague Electric Works of General Electric Company. Bulletin No. 48713; 8 x 10½; 16 pp., illustrated. Descriptive of the "Sprague Adjustable Loop System" for overhead material handling machinery applicable to terminal sheds for the temporary storage of freight or materials before loading or after unloading from ships, barges, or railroad cars, the primary purpose being to speed up the movement of freight, to reduce cost of handling, to utilize shed space to the fullest extent, and to relieve congestion at loading and unloading points.

**Storage Battery Driven Locomotives, Cranes and Cars.** The Atlas Car and Manufacturing Co., Engineers and Manufacturers, Cleveland, Ohio. Bulletin 1185, 6 x 9; 48 pp.; illustrated. Describes the company's line of standard storage-battery equipment. Special types of locomotives and cars for particular uses are also designed. Details are included of the drive unit, in the manufacture of which the motor cradles have been designed for accessibility, protection and elimination of twisting strains; of the motors, which have the armature mounted on ball bearings packed in grease and permit armature to be readily removed without disturbing coils, and of the charging equipment, made on the sectional system, as well as the battery, meter, controller, and other parts.

**Direct Current Motors and Generators.** Allis-Chalmers Manufacturing Co., Bulletin No. 1096-A, 8 x 10½; 20 pp.; illustrated. Describes types "K" and "KC". Special features of type "K" are the well-proportioned, cast-steel yokes, substantial housings, large bearings with interchangeable bushings, and rigid shafts, the motors being well adapted to belted, geared or direct-connected service and for either continuous or intermittent duty. In the manufacture of these motors a complete line of jigs and special tools is employed, and the interchangeability of all the parts is thus assured. Improvements in materials and methods of installation have been made, and these, with moisture-proof coils and dust-proof bearings, insure long life and reliable operation, even in exposed situations. Type "KC" has been introduced to provide a motor with a wide range of speeds. Speed adjustment is made through field control. Through the addition of commutating poles, sparkless commutation is secured when motor operates at maximum speed with weakened field.

## New Patents

United States patent specifications may be obtained from "The Engineering and Mining Journal" at 25c. each.

**Leaching**—Metallurgical Process. Carlos Malsch and Carlos Hennes Gilson, Valparaiso, Chile, assignors to Sociedad Metalurjica Chilena Cuprum, Valparaiso, Chile. (U. S. No. 1,303,701; May 13, 1919.)

**Lead Arsenate**—Method of Making. Iens P. Lihme, Lakewood, Ohio, assignor to the Grasselli Chemical Co., Cleveland, Ohio. (U. S. No. 1,302,186; Apr. 29, 1919.)

**Petroleum**—Working Barrel for Oil-Well Pumps. William A. McGregor, Bradford, Penn., assignor to McGregor Working Barrel Co., Inc., Bradford, Penn. (U. S. No. 1,301,068; Apr. 15, 1919.)

**Potash**—Process and Apparatus for Separating Finely Divided Materials. Walter A. Schmidt, Los Angeles, Calif., assignor to International Precipitation Co., Los Angeles, Calif. (U. S. No. 1,298,409; Mar. 25, 1919.)

**Process for Clearing Clayey Ores.** Edward F. Goltra, Thomas S. Maffitt and Jesse D. Dana, St. Louis, Mo., and Robert W. Erwin, Waukon, Iowa, assignors, by mesne assignments, to Mississippi Valley Iron Co., Wilmington, Del. (U. S. No. 1,301,684; Apr. 22, 1919.)

**Pulverized Fuel**—Automatic Apparatus for Distributing Pulverized Fuel. William O. Renkin, Oradell, N. J., assignor to Quigley Furnace Specialties Co., Inc. (U. S. No. 1,301,168; Apr. 22, 1919.)

**Sample-Taking Device.** Walter Lee Church, Humble, Tex. (U. S. No. 1,300,346; Apr. 15, 1919.)

# Editorial Correspondence

### SEATTLE, WASH.—June 19

**Good News Bay**, near mouth of Kuskokwim River, is the destination of a U. S. Geological Survey party that left Seattle on June 16 on schooner "Ozmo." R. H. Sargent, topographical engineer, is in charge. Accompanying is G. L. Harrington, geologist. Data on geology and mineral resources will be collected.

**The Talkeetna Bridge**, 2200 ft. long, has been completed on the Government railroad 103 miles north of Anchorage, Alaska. At Jualin, bids have been received from several on what is to be the longest mine tunnel in years. Successful bidder should be known soon. At Nome, the first two boats of the season have arrived, but are unable to land, on account of ice floes.

**Lost River Tin Mines**, 100 miles from Nome, Alaska, are to be developed by the owner, James F. Halpin. Erection of a mill is considered when sufficient tonnage has been developed. Equipment now being assembled. Steamer "Cordova" left Seattle June 15 with 600 or 700 tons of equipment and will make special landing. Shipment includes three compressors, drills, hoists, fans and other necessary appliances. Next winter about 30 expect to stay at mine, and suitable buildings will be erected.

### SAN FRANCISCO, CAL.—June 19

**Two Gas Wells** bought in by Standard Oil Co. at Elk Hills now making 100,000,000 cu.ft. of gas a day. Property was bought not long ago for $25 an acre. In addition to these gas wells, the Standard Oil has three producing oil wells.

**The Present Scarcity of Labor** in California mines is largely owing to the fact that wages in general throughout the state are little higher for underground work than for surface work, such as dams, highways, and construction work in general. The recent strike at Grass Valley, an account of which is given on another page, is an outgrowth of these conditions.

**The Estabrook Gold Dredging Co.** has put in operation the recently completed 20-cu.ft. gold dredge on Trinity River in Trinity County. Results have been entirely satisfactory on this boat, reported to be the largest wooden gold dredge in the world. The cost was in excess of $600,000. It is 152 ft. long, has a 68 ft. beam, and draws 10 ft. of water. In construction 1,000,000 ft of lumber, cut from the surrounding forests, was used.

**California Oil Prices** posted by the Standard Oil Co. and effective June 10, 1919, represent a slight increase over prices scince May 1, 1918. These prices will no doubt, as formerly, govern all sales. For San Joaquin Valley fields the prices are as follows: 14 deg. to and including 17.9 deg., $1.23 per bbl.; 18 deg. to and including 18.9 deg. $1.24 per bbl.; 19 deg. to and including 19.9 deg., $1.25 per bbl., and for each increase in gravity of one full degree above 19 deg. gravity up to and inclusive of 36.9 deg., 2c. per bbl. additional; 37 deg. to and including 37.9 deg., $1.62 per bbl., and for each increase in gravity of one full degree above 37 deg., 3c. per bbl. additional. Practically the same prices apply to the Whittier-Fullerton and Santa Maria fields and represent an increase of from 1c. to 5c. per bbl., according to the gravity of the oil.

### PHOENIX, ARIZ.—June 19

**The Arizona Employers' Liability Law** is held to be constitutional by the decision of the U. S. Supreme Court rendered June 9, affirming the judgment of the Federal court in the cases of Richard Bray and Joseph Hammer against the Arizona Copper Co., Ltd. The latter company and other companies were represented at the hearing by John A. Garver, of New York; Senator William H. King, of Utah, and Judge E. W. Lewis, of Arizona. Both of the above cases were appealed to the Supreme Court upon the ground that the Employers' Liability act, under which the cases were prosecuted, deprived the company of its property without due process of law, in violation of the Fourteenth Amendment of the Federal Constitution. The cases on appeal were heard before the U. S. Supreme Court during the latter part of January, 1918. The liability act provides that in cases of appeal judgments carry interest at the rate of 12 per cent.

### WALLACE, IDAHO—June 19

**Robert M. McWade**, of Washington, D. C., U. S. Conciliation Commissioner connected with the Department of Labor, is in the Coeur d'Alene district for the purpose of adjusting the differences between the mine operators and the International Union of Mine, Mill and Smelter Workers. The circumstances leading up to his coming are set forth in the *Journal* of June 21. Since his arrival he has conferred with representatives of the union and with the mine managers individually. It appears that Mr. McWade's idea of "conciliation" is for the mining companies to tie up with the union, and his argument is at least novel. He assumes that all good citizens are opposed to the I. W. W. He then points out that the I. W. W. is quite strong in certain sections of the district, and that the miners' union is the enemy of that organization. Therefore, he concludes, in order to combat the I. W. W. successfully, the mining companies should recognize and back up the union.

### SALT LAKE CITY, UTAH—June 19

**A Semi-Monthly Pay Day,** provided for at the last session of the State Legislature, is now in effect at Utah mines. The law also requires that "Whenever an employer discharges an employee, the wages earned and unpaid at the time of such discharge shall become due and payable immediately. When any such employee not having a contract for a definite period quits or resigns his employment, the wages earned and unpaid at the time of such quitting or resignation shall be due and payable at the employee's next regular pay day.

### DENVER, COL.—June 20

**Separate Leasing Bills** for coal and oil-shale lands have been introduced in the House by Congressman Taylor, of Colorado. These bills are identical with the coal and oil-shale sections of his general leasing bill. Ferris, of Oklahoma, and Raker, of California, have introduced similar bills almost identical in language.

**Recent Discoveries in Barstow Mine,** near Red Mountain, Colo., have caused considerable interest locally. The mine has at various times produced considerable rich gold-silver ore, and shipped 1500 tons of fluorspar last year. The discovery was made by the Lundberg-Curtis Lease, of Ouray, an association that subleased a block of ground last winter. Drifting 500 ft. on the vein last year by the Barstow Lease, which operates the property, disclosed an apparently insignificant streak of gold-bearing quartz. This was two to six inches wide and five feet long, but carried good gold and silver. Stoping on this streak has disclosed an orebody 75 ft. long and up to five feet thick, at a height of 90 ft., with the length still increasing as the stope continues upward. Most of the ore won so far is considered only good milling ore, being around one ounce gold by assay, with some silver and lead. The Lundberg-Curtis Lease plans to improve the present stamp mill by equipping it with a small re-grinding and flotation outfit, for the summer's milling run.

### EDGEMONT, S. D.—June 20

**The Mule Creek Oil Field** in Converse County, Wyo., and near Edgemont, S. D., is receiving considerable attention, and indications point to a productive field. Though the district is a new one, drilling has disclosed oil at shallow depths. New rigs are being set up weekly and operators are active in pushing the work. The Ohio company has three wells drilling, and three rigs are to be set up as soon as they can be shipped in. In all probability this company will have six rigs at work within the next 30 days. The Midwest company has one rig ready to spud in, and the Stanley Greene company is erecting two outfits for the same company. The entire field is one of activity, and much is expected in the way of oil production.

**The Richards Oil Syndicate** has been formed to investigate the oil field in the Rocky Ford district, in Crook County, Wyo. Richard Blackstone, of Deadwood, formerly superintendent of the Homestake Mining Co., is president, and E. P. Peterson, of Terraville, secretary and treasurer. Smith Willey, of Deadwood, will have charge of the drilling. They have secured 640 acres of land four miles east from Sundance and 100 acres in the Rocky Ford district, where wells have heretofore been drilled and oil encountered at 150 and 200 ft. The oil that has been found in the wells is of high-grade asphalt quality. The new syndicate is completing arrangements for a new rig, and the field will be thoroughly tested, beginning with a 10-in. hole.

### JOPLIN, MO.—June 21

**Night Classes in Practical Mining** have been started at Galena and Baxter Springs, Kan., as the result of agitation by Prof. T. E. Terrill, formerly with the Kansas State University.

**A New Record for Initial Production** by a moderate-sized concentrator in the Joplin district was made by the Big Elk plant during the last week. Operations were started on June 19, and the first hour five tons of zinc concentrates was made, and during the day 29,000 lb. of zinc and 5500 lb. of lead from 41 tons of mine-run ore. The mine lies between the Southern and Silver Fox properties, northwest of Picher, Okla., in Kansas, the office of the company being at Miami, Okla. J. T. Worley, of that city, is president. Chicago-Pneumatic gas engines are furnishing power.

**Sale of the High Five Mine,** at Waco, Mo., for $250,000, has been announced. The property includes a 70-acre lease, a developed mine, and a concentrator of 400 tons' capacity per shift. George Ball and associates, of Webb City, developed and sold the property, the buyers being Temple Chapman, of Joplin, and George E. Starr, of Philadelphia. Mr. Starr formerly was an operator in the district. Drilling at the property has indicated an orebody approximately 95 ft. in thickness. Development has been slow, on account of a heavy head of water, but this is gradually being eliminated by pumping by a number of different companies. The mill is new and has been operated only a few days. Full operation will not be started before July 4, and possibly not until later, Mr. Chapman being one of those favoring drastic curtailment of production.

### ST. LOUIS, MO.—June 20

**St. Louis, as an Oil-Refining Center,** possesses advantages that are now being realized. With its central location in the heart of the Mississippi Valley, with 22 radiating railroads and its situation on the Mississippi River, the distributing facilities are exceptionally good, and there is also a local market of over one million people that absorbs a large amount of fuel oil in the large opennearth steel plants. There are three small refineries in East St. Louis. The Standard Oil Co. built a large refinery at Wood River, which now has a capacity of 15,000 bbl. daily; and the Roxanna Co. built a 5,000 bbl. refinery at Wood River, in the last year. The Tide Water Oil Co., which has a large exporting refinery in New York Harbor, has just purchased a 231-acre tract at Wood River for a new refinery, and the White Star Refinery has purchased a tract of 60 acres at the same place on which to build another large oil refinery. The Standard Oil Co. has two pipe lines to the Oklahoma fields and another pipe line to Eastern Illinois fields, and the Roxanna company has just completed its own pipe line to the Oklahoma and Texas oil fields.

### DULUTH, MINN.—June 20

**John A. Savage & Co.,** independent iron-ore operators of Duluth, Minnn., have received a verdict in district court against C. A. Remington, of Hibbing, in the amount of $2300 in a suit involving the stockpile of the Elizabeth mine at Chisholm. It developed at the trial that the mining company in 1918 had purchased the 55,000 tons of stockpile ore at a certain analysis, but that after shipment of 27,000 tons had been made the average silica content proved to be about 12%, instead of about 8.50%, as expected, whereupon the buyer refused to ship any more of the ore. Remington then sued for $60,000, based not only on the 27,000 tons shipped, but also on non-fulfilment of contract in refusing to ship the remainder of the pile. It was held by the court that iron ore is sold on analysis and that any wide misrepresentation is a violation of contract. The case will be appealed.

**The U. S. Bureau of Mines** has recently issued a bulletin setting forth the outcome of experiments conducted in coöperation with the Minnesota School of Mines on what is termed the "Jones Process for Concentrating Manganese Ores," perfected by John T. Jones. The bulletin sets forth the process as follows: "The process consists of two stages. In the first, called the low-temperature reduction stage, two products are made, namely, (a) metallic iron, suitable for direct use in the manufacture of steel, and (b) slag. Most of the manganese is concentrated in the slag. Separation of these two products, as outlined by the inventor, is accomplished by grinding of the sinter resulting from the low-temperature treatment of the ore, and thereupon extracting the magnetic iron pellets by means of magnetic-separation apparatus, producing thereby a high-grade magnetic iron concentrate, and a non-metallic manganiferous sinter. This method was used in the preliminary tests. In the final tests, however, separation was accomplished by pouring the material under treatment in a liquid condition and recovering the iron metal in the form of a button. The second stage, which may be called the high-temperature stage, involves the smelting of the manganiferous slag or sinter derived from the first stage, to produce a manganese alloy." The bulletin does not attempt a discussion of the commercial possibilities of the process, but concludes that the metal produced in the low-temperature process is suitable for conversion into steel by any basic steel process, and that the alloy produced by the high-temperature process might be termed a silico-ferro-manganese, and, though new to the steel-manufacturing industry, at this time could probably be used to advantage. About 72% of the manganese in the ore appears in the alloy.

### HOUGHTON, MICH.—June 21

**The Labor Situation** in the Michigan copper district has taken a sudden change, and men have become scarce. Sixty days ago the mines were decreasing their force and curtailing production 50%. In all twenty-five hundred were discharged or quit, the majority being surface employees. Today every mine in the district could use more trammers and miners, and is endeavoring to get general physical conditions underground in healthy condition. This is a unique situation in the copper country.

**Crosscut From the Seneca Shaft** showed the lode 22 ft. wide, carrying copper all the way across, except for one horse of trap. Drifting on the lode has begun, the shaft now being cemented. This will be the first Seneca drift, and the opening on the formation will be watched with interest. It is necessary to go 100 ft. in the shaft to get out of the curve from the vertical to the incline. Then sinking will be pushed more rapidly. Seneca's purchase of Gratiot from Calumet & Hecla will not only add 3318 acres to Seneca's holdings, but will furnish necessary ventilation through the Gratiot shafts. Gratiot carries the Kearsarge amygdaloid under 175 acres and to a maximum depth of 2700 ft. Two shafts were sunk by the Calumet & Hecla following diamond-drill explorations. The first is 1500 ft. from the Seneca line, and is 1900 ft. deep, with levels every 200 ft. The second shaft, 1475 ft. southwest of No. 1 and 1800 ft. north of Mohawk line, went down 1520 ft., four levels being opened. Copper rock which went to the mill did not show 10 lb. to the ton. Ojibway, adjoining, contains 1560 acres and has two shafts, one down 2051 ft. and the other 1954. Work developed interesting geological conditions of the Kearsarge lode, as formation showed seven alternations of trap and amygdaloid, all above sandstone horizon.

### ISHPEMING, MICH.—June 21

**Iron-ore Shipments** continue light from the Lake Superior district. The only heavy shippers are the Oliver Iron Mining Co. and Pickands, Mather & Co., both of which have excellent furnace connections. The Oliver company which is the mining branch of the U. S. Steel Corporation, is replenishing its stocks at the furnaces, it being the policy of the parent company to maintain large stocks of raw materials at its plants in Illinois, Indiana, and in the East, in order to be prepared against labor troubles and transportation difficulties. Only a small amount of ore is going forward from the stockpiles, and some of the operators are still placing the daily hoist in stock at the mines. Additional stocking space must be prepared at many of the properties. It is difficult to state just what is going to transpire the coming winter, but it is feared that some of the independents will have to curtail operations considerably unless the ore market takes a decided turn for the better within the next few months. The manager of one of the largest of the independent concerns stated a few days ago that his company had disposed of only one-fifth of the amount of ore that is usually sold at this season of the year. As one looks over the stockpiles of ore at the mines one cannot help but feel that the market is not in a healthy condition, although reports from the iron and steel centers state that steel is improving. Vessel owners are advising the ore men to move their ore during the summer, as the boats will be busy carrying grain during the fall months. In spite of the fact that the ore market is not in the best of condition, wages have been maintained throughout the district and few men are out of work. This is in great contrast to the copper districts, where forces have been reduced and wages lowered. The independents are hopeful that the ore situation will improve in time to permit them to move all or a part of their surplus stocks this year.

### BIRMINGHAM, ALA.—June 20

**Iron-Production Figures for May** from the Birmingham district do not show the increase over April that was expected, but the situation as a whole shows marked improvement throughout the month. The renewed activities of some companies, particularly Woodward Iron Co., and the tendency of others to swing back to normal production and sales, are responsible for the optimistic views held by both producer and consumer. The attitude of the consumer is expressed in many small orders for iron for immediate delivery and inquiries regarding large orders for future delivery. It is believed that if the business offered for delivery during the last half of the year is accepted, between 100,000 and 200,000 tons of pig iron will be sold this week. That producers are expecting the upward swing in business is indicated by their renewed operations and the refusal of

some to quote prices on iron to be delivered after October, 1919. Further proof of better conditions in this district is noted in the intra-district freight records. The volume of freight moving is gradually increasing to the point where it is believed the Sunday trains will be running soon, possibly before the end of the month.

Two furnaces of the Tennessee Coal, Iron & Railroad Co., at Bessemer, Ala., are to be blown in soon, it is expected. This done, the company will have four in operation in Bessemer, and this increase, with the Woodward furnaces operating, will tend to better the conditions in the mining camps along Red Mountain.

The labor situation in the Birmingham district is causing some trouble. The larger companies report a surplus at their mills and furnaces but serious shortages in their mining divisions. There seems to be no desire on the part of the men to go to the mines, and as a result large numbers of idle negroes can be seen on the streets in the district looking for transportation North or work at the furnaces or mills. There has been some shipment of labor north, particularly noted in Bessemer, Ala. This is an injustice to the district, and more so to the men shipped, for the negro is prone to ride the train on the slightest pretext, and the majority of negroes, after reaching their destination, go through many hardships before finally drifting back South.

An attempt is to be made to organize men employed in the Birmingham iron and steel industry into unions which will be affiliated with the American Federation of Labor. No statement from the larger companies as to their stand in this matter has been received, but it is believed they will bitterly oppose all attempts to organize. Samuel Gompers, president of the American Federation of Labor, has promised to send a number of organizers to the district at once, and mass meetings will be held in the near future in all centers in this district, particularly Ensley, Bessemer, Woodward and Westfield.

Suits for damages, totaling about $200,000, have been filed in the U. S. District Court against the Woodward Iron Co. by G. D. Walker and Raymond Fuqua. The company's employees are charged with negligence in the handling of a switch engine and some cars which crashed into a truckload of young people on a picnic recently, resulting in the death and injury of several.

**TORONTO, ONT.—June 21**

**The Labor Troubles in Northern Ontario** seem to be clearing, and the general impression is that there will be no strike in Cobalt. The result of the strike vote was announced on June 15, and showed a large majority in favor of the strike. However, the vote represented only about 50 per cent of the workers of the camp, and, as is the general rule, the men who were satisfied took little interest in the matter. With the high wages being paid and the prospect of still higher wages as silver keeps to its high level, a large number of the men, and particularly those who are married and have families, apparently have no desire to see a strike. In Kirkland Lake, when the men went out, the mines closed and made no attempt to operate, and as a result everything is shut down.

**The Supreme Court of Canada** has handed down a decision in the appeal taken by the Dominion Reduction Co. from a decision of the Supreme Court of Ontario in the action against the Peterson Lake company over the ownership of tailings. The case arose over the fact that for some years the Dominion Reduction Co. had been depositing its tailings in Peterson Lake, with the permission of the Peterson Lake Mining Co. When silver began to rise, the Dominion Reduction Co. wanted to re-treat the tailings, but the Peterson Lake Company claimed ownership. There are estimated to be 220,000 tons of tailings in the lake. The Peterson Lake got the decision in the two lower courts, and the appeal by the Dominion Reduction Co. was dismissed with costs.

**MELBOURNE, AUSTRALIA—May 1**

**Ore Raised From Broken Hill Mines** during 1918 totalled 1,251,161 tons, an increase of 219,802 tons over 1917. The output was valued at £6,232,931, and dividends paid amounted to £1,253,571. In addition to the foregoing, the zinkiferous tailings treated were valued at £576,952, and returned to shareholders £328,900. Of the individual mines, the output from the Proprietary again heads the list, with a value of £1,709,294, with that of the South Mine £1,189,238, and the Sulphide Corporation (Central Mine) £1,042,112.

**The Mount Morgan Gold Mining Co.** announced under date of May 3, that the output of copper since October last, totalling 3400 tons, remains unsold. Notwithstanding this, it is considered advisable by the directors to maintain productive operations, but they have announced that this policy will render it advisable not to declare any dividends for the present. An official notice to shareholders states: "Your directors find difficulty in expressing definite views, with regard to the immediate prospect of an alteration in the position. There has been a heavy curtailment of production in America, but the expected industrial demand is still absent." Apart from Mount Morgan, Mount Lyell is the only important copper producer in Australia that is still at work.

**The Mount Boppy Gold Mining Co.** Canbelego, N. S. W., is the premier gold producer in New South Wales, but is gradually coming to the end of its resources. During 1918 a total of 61,176 tons of ore was raised, for a production of 15,511 oz. gold, valued at £65,329. As the remodeling of the mine plant was not completed until early in the year, and operations were suspended in November owing to water shortage, a full year's work was not possible. A new main shaft was completed, making available large bodies of ore around the old shaft, which previously could not be removed. This ore is being taken out by means of two open cuts, one on each leg of the lode. In addition, a fair quantity of ore remains in several of the stopes underground. J. Negus, who has been to London to consult with the directors, is now on his way back to Australia. He has an option on the Occidental Gold Mine at Cobar, said to be a very promising property.

# The Mining News

## ALASKA

ALASKA SHIPMENTS of domestic copper ore, matte, etc., to United States during May were 1,134,272 lb., having value of $176,129.

## ARIZONA

### Cochise County

WOLVERINE & ARIZONA (Bisbee)—Copper-ore shipments to smelters suspended during April and May. Development of new orebody has added greatly to ore reserves.

### Gila County

BARNEY COPPER (Globe) — Stockholders met June 2 to change company name to Porphyry Consolidated Copper Co., and to change par value of shares from $5 to $1 and number of shares from 1,000,000 to 5,000,000, capitalization to remain same. Col. J. D. Coplen president of both companies.

### Mohave County

THUMB BUTTE (Kingman)—New machinery and telephone line just installed preparatory to resuming operations, after two years' idleness. Property carries strong fissure vein of gold-silver ores, and has been developed to the 400 level.

### Pinal County

SOUTH RAY COPPER (Kelvin)—Unwatering operations have reached 350 level. Force of men put at work on 300 level. Mine will be completely unwatered and extensive development done on 500 level. New mining equipment being installed. W. B. Duvall in charge.

U. S. VANADIUM DEVELOPMENT (Kelvin)—Small force of miners at work in lower levels doing exploratory work. Property being thoroughly sampled. Exhaustive study of geology and occurrence of ores being made. Mill to be remodeled for experimental plant.

RAY BROKEN HILLS (Ray)—Development tunnel driven over 1200 ft. Body of gold ore, developed in shaft 500 ft. above, over 100 ft. in width, where cut by tunnel. Flow of water recently encountered in tunnel approximately 100 gal. per min. Company has recently acquired Alma group of 10 claims from J. A. Tillman and Little Bobbie group on west and south, respectively. Large force of men employed under Scott Litner. Property recently surveyed for patent.

### Yavapai County

U. V. EXTENSION (Jerome)—Plans call for starting and gradually increasing smelter operations in near future upon completion of certain changes in reverberatory department.

STODDARD (Stoddard)—Sinking of main shaft being pushed by three shifts under S. E. Chaney, superintendent.

## CALIFORNIA

### Butte County

SURCEASE (Big Bend)—Reported deal pending between Goldfield Consolidated Mines Co. and Julius Kruttschnitt, Jr., for purchase of Surcease mine.

### Eldorado County

KELSEY GROUP (Placerville) — Examination made by E. K. Finn, of New York. Reported that mine plant and mill will be installed.

### Nevada County

NORAMBAGUE (Forest Springs)—Announced operations will be resumed. Worked by Prentiss & Pell before war conditions necessitated shutdown.

### Plumas County

GOLDEN EAGLE GROUP (Quincy)—Placer-mining claims transferred by Nelson & Merrimac to Fisher Brothers, of Oakland, Cal.

### Sierra County

TABLE ROCK (Table Rock)—Recently completed 3000-ft. tunnel to secondary channel, where commercial ore was uncovered. J. H. Hartley manager and Francis Gay principal stockholder.

### Inyo County

PETERSON BROTHERS cut small blind vein at Caliente in Amalie district while running crosscut in water well for storage purposes. Vein said to be heavy sulphides of good grade.

BISHOP CREEK (Bishop)—Shipping concentrates from old mill tailings. Mine now unwatered and conditions satisfactory for steady production of about 75 tons per day. Cooper Shapely manager.

### Nevada County

EAST EUREKA (Grass Valley)—Recently sold to Metals Exploration Co. by David Whildin, of Grass Valley, for $11,000.

CALIFORNIA MINING (Nevada City)—Tunnel being run to gravel deposit in Harmony Ridge now in 650 ft. and advancing about 110 ft. per month in hard granite. Company's ground four miles long, two miles wide. A. Hoge, superintendent.

### Tuolumne County

COLUMBUS GROUP (Tuolumne)—Option on purchase for $50,000 granted to Murray Innes and L. D. Gordon, of San Francisco, by owners, Columbus Mining Co., principal stockholders of which are J. Goldman and S. G. O. King. Terms of agreement call for payments distributed over period of 4½ years, with royalty of 10 per cent on net proceeds to be applied on purchase price.

## COLORADO

### Boulder County

SMUGGLER (Jamestown)—Property at Balarat being developed by new Smuggler M. and M. Co. New orebody opened on

200 level south of main shaft. South heading being advanced. Will crosscut to prospect for parallel veins. Construction of small milling plant under consideration. T. W. Clements general manager, G. R. Prunty secretary-treasurer, and Melvin Brugger superintendent.

**Lake County**

WELDON (Leadville)—Leased to Griffin and Callahan, who are placing property in operating condition, and plan considerable underground development. Much zinc carbonate ore opened in upper workings.

**Ouray County**

GUADALUPE (Ironton)—Much development work done during last winter and commercial ore opened. Mill completed, and cable tramway will be built from mine to mill. Bond and lease secured on Beaver, Belfast and Ida L. properties. Reported 25,000 tons of ore blocked out and ready for mining. Shipment of 55 tons of smelting ore recently settled for at Salt Lake City.

**San Juan County**

GOLD KING (Gladstone)—Recent development work opened for 200 ft. payable oreshoot about 15-ft. wide. Estimated ore reserves available will supply 300-ton mill throughout present season. About 80 men employed in mine and mill.

**San Miguel County**

SMUGGLER-UNION (Telluride)—Will build one-story addition to boarding house at Sheridan adit, and at Smuggler a 3½-story addition to boarding house and an apartment house of 4-room apartments for family use. Latter will be 26 x 116 ft. and 3 stories high. Building contract awarded to Harry Doyle, of Telluride.

## IDAHO

**Bonner County**

CLARINDA COPPER (Clark's Fork)—John K. Ashley surveying route of proposed tunnel No. 4; tunnel to start at Northern Pacific R. R. and to cut all veins. Ore of shipping grade, principal value silver; also considerable milling ore. Compressor and machine drills being installed. J. P. Delaney, secretary. Project financed by Delaney & Co., 50 Broad St., New York.

**Boundary County**

IDAHO CONTINENTAL (Porthill)—Operations resumed with over 100 men. Mine on two shifts, mill on three.

**Shoshone County**

HECLA (Burke)—Drift on 2000 level struck foot of good ore 350 ft. in advance of point where oreshoot was expected, corresponding with ore on 1600. Good milling grade and believed to be beginning of main oreshoot. Carries considerable zinc. Ore in upper working practically free of zinc.

MARSH (Burke)—After long suspension work started to explore promising ground on main tunnel level. Shaft, now down 900 ft., abandoned for present. Hoist sold and removed from property.

BUNKER HILL & SULLIVAN (Kellogg)—Fire destroyed large supply of stull timbers and sawmill. Loss estimated at $150,000.

## KANSAS

**Joplin District**

REDSKIN (Miami)—Resumed operations after shutdown of several weeks. Will start sinking north of mill soon to intercept ore run that has been dipping that direction. E. B. Edes, of Joplin, active manager once more, after recovering from influenza and pneumonia.

SOUTHERN LEAD & ZINC (Miami, Okla.)—Preparing to sink to take out 15 ft. of ore which could not be mined before without heavy water, but entire head of water has been lowered. H. S. Clarke, secretary-treasurer, P. O. Box 676, Miami.

## MICHIGAN

**Copper District**

HANCOCK CONSOLIDATED (Hancock)—Shareholders, at their annual meeting, elected the following directors: John D. Cuddihy, Thomas Hoatson, James Hoatson, A. F. Rees, W. R. Thompson and John Hicok. Directors elected John D. Cuddihy president, Thomas Hoatson, vice-president, and John Hicok secretary and treasurer. Sale of 125 acres of mineral land to Quincy authorized without opposition. Active operations can be resumed on short notice. All work suspended, but pumps running. Physical condition excellent. Two east branches of Pewabic in good ground that will yield 17 lb. per ton.

QUINCY (Hancock)—Management has announced it will give underground work to all returned soldiers seeking it, whether formerly employees or not. No surface positions open.

MOHAWK (Mohawk)—May output of refined copper 1,052,738 lb. Wolverine produced 352,130 lb.

**Iron District**

**Gogebic Range**

NEWPORT (Ironwood)—Inventory made by Pickands-Mather & Co. experts. According to rumor, this was done for large bonding house, preparatory to issue of bonds by Newport Mining Co., but officials refuse statement.

TOWNSITE (Ironwood) — Deal made with Republic Iron & Steel Co. to handle ore from Townsite mine. Herbert E. Jussen has returned from Marquette Range and will act as superintendent for Republic company. Shipment from stockpiles begun.

PURITAN (Puritan)—Work in progress to connect workings with those of Ironton mine to provide outlet for miners in case of accident to shaft, Davis shaft outlet having been temporarily lost because of fire in same.

**Marquette Range**

STEPHENSON (Gwinn)—Pumps steadily gaining on water. Some months yet before operations can be resumed underground.

CLEVELAND-CLIFFS (Ishpeming)—Several diamond drills working in Ishpeming and Negaunee fields. Some using steel tripods with 50-ft. rods. Expected some new deposits will be discovered.

NORTH LAKE (Ishpeming)—A 10,000 ft. drift being extended to Barnes-Hecker at depth of 600 ft. Will be used for exploratory and development purposes.

OHIO (Michigamme)—All ore in stock to be shipped. Mine not operating.

## MINNESOTA

**Mesabi Range**

LAURA-DAY (Hibbing)—Prospect being drilled by Pickands-Mather & Co. Near Albany mine of same company.

HILL (Marble)—Great Northern lease, which has not shipped since 1916, taken over by Cleveland-Cliffs. Contains large tonnage of wash ore, which will necessitate concentrator later.

ENTERPRISE (Virginia) — Conducting supplementary test-pitting operation.

NORMAN (Virginia)—Famous property of Oliver Iron Mining Co. completed career recently with shipment of last car of ore. Opened in 1894, shipped 6,000,000 tons, figured in several fee-owner-operator lawsuits, and has been scene of one of worst accidents in Mesabi Range mining history.

## MONTANA

**Beaverhead County**

BOSTON & MONTANA DEVELOPMENT (Wise River)—Crosscut from Upper Idanha tunnel at Elkhorn mines advancing at rate of over 400 ft. monthly, 111 ft. being made last week. Raise from 1000 level on the Idanha fissure now up 400 ft., several sets being made weekly. Ore showing continues strong in raises.

**Jefferson County**

LEGAL TENDER (Clancy)—Syndicate of Butte men secure control and active development program under way. Ore high in silver, but fissure narrow, and yet to be picked up beyond faulted section. Carload of ore shipped last week.

**Missoula County**

POTOMAC COPPER (Potomac)—Road building, connecting properties with Potomac, eight miles distant, completed, and grading in progress for foundation for air compressor plant and miners' boarding house.

**Silver Bow County**

ANACONDA (Butte)—Custom zinc ore shipments increased, according to tonnage statement from Great Falls electrolytic plant, capacity of which is being increased from 100 tons daily to 150. New copper refinery at Great Falls now has capacity of 16,500,000 lb. of metal monthly, which can be enlarged to 21,500,000 lb. by operating old refinery in conjunction with new plant. Copper production slightly better than 50 per cent. Experienced miners scarce.

BUTTE-BULLWHACKER (Butte) — Mining operations will be resumed July 1 and shipments started to Washoe leaching works at rate of 250 tons daily.

BUTTE & RAMSDELL (Butte)—Ore shipments resumed last week through medium of Davis-Daly company, whose veins are leased in Ramsdell territory. Royalties paid Davis-Daly range from 10 to 25 per cent. Last 90 cars shipped averaged 6.20 per cent copper.

BUTTE & SUPERIOR (Butte)—When No. 2 shaft of Black Rock mine reaches 2,500 level crosscut will be driven to No. 3 shaft and that raised from 2500 to 2000 level. Orebody on 1800 and 1900 levels now opened for more than 1600 ft.

DAVIS-DALY (Butte)—Contract awarded to Minneapolis Steel & Machinery Co. for immediate installation at Colorado mine of skips, skip dumps, and steel and concrete ore bins. Skips will enable hoisting of increased tonnage, and capacity of bins will be enlarged from 150 to 600 tons. Timber being hauled to Hibernia mine, preparatory to sinking shaft additional 50 ft. to crosscut at 500. Shaft now down 400 ft.

TUOLUMNE COPPER (Butte)—Sinbad shaft of Main-Range mine now down approximately 135 ft. below 1,000 level and station cutting underway at this depth. Daily ore shipments approximating 100 tons. Showing on 500 level improving, as drift is carried westerly to zone corresponding with section opened on 700 and 800 levels.

## NEVADA

**Lincoln County**

PIOCHE DISTRICT ore shipments for week ended June 12 were: Prince Consolidated, 24 cars; Virginia-Louise, 6 cars; Black Metals, 6 cars; Harney, 2 cars.

BLACK METALS (Pioche)—Increasing shipments of fluxing ore. Struck new vein of high-grade ore on seventh level.

**Nye County**

TONOPAH HASBROUCK EXTENSION (Divide)—Judge Walsh, at Goldfield, has decided in company's favor in suit against Silver King Divide involving surface conflict between Independence No. 1 lode and Silver King No. 1 lode. Court held Independence No. 1 was valid location and that Silver King No. 1 could not by making excessive location in first instance amend its lines as against junior Independence No. 1 so as to claim more than 300 ft. from location monument.

**Storey County**

MONTE CRISTO (Virginia City)—Old property formerly owned by Charles Butters Co., Ltd., of London, sold to Monte Cristo Mines Co., newly organized by R. R. Hillman, Morris Rosenthal, I. E. Selix, and others. Purchase includes all rights of way, mill site, and over 700 acres of land in Storey County; also 25,000 tons of tailing from other companies. Will start operations soon, using part of old Butters equipment. Will probably buy other equipment.

## NEW MEXICO

**Grant County**

ATWOOD (Lordsburg)—H. V. Snell, of Globe, Ariz., has purchased controlling interest from Morningstar & Augustine, in Southern and Atwood groups, which join 85 Mine on the southeast. Development will be started soon.

BOSTON-HECLA (Lordsburg)—Receiving bids from contractors for 300 ft. double-compartment shaft. Fred Kroll, superintendent in charge.

CO-OPERATIVE (Lordsburg)—Has installed 20-h.p. hoist and 100-h.p. boiler and is working on mill foundations. E. Walters, superintendent.

EL DORADO GROUP (Lordsburg)—Six-months' option taken upon this group of mine claims by Inderreiden, Coon, and Ritter from Fairley and Killebrew, owners. Group of five claims adjoining 85 Mine on west also optioned from Killebrew and Malone.

LAST CHANCE (Lordsburg)—Has arranged to pump sufficient water to keep mill working full time.

OCTO (Lordsburg)—Main shaft down 160 ft. Working 25 men. E. K. Davis superintendent.

STEVENS (Lordsburg)—Property unwatered. Nine feet of ore reported on 200 level. Will be worked by local syndicate. B. Ford superintendent.

## OKLAHOMA

**Miami District**

BLUE MOUND (Baxter)—Has taken over and will develop Lucky Strike lease, south of St. Louis, Okla. Tract at one time had concentrator, but heavy water prevented operation. About same time president of company died, and mine has been idle since.

OMAHA LEAD AND ZINC (Joplin)—New mill in operation. Will sink shafts 20 ft. or more to deeper run. Plant handling 400 gal. of water per minute. Mark R. Moore, Okmulgee, Okla., president. T. N. Chenoweth, Joplin, superintendent.

STANDARD LEAD AND ZINC (Joplin)—Operations again started on lease north of Tar River. Mine supposedly owned by Erdly Brothers, who are with Chanute Spelter Co. here.

DEFENDER (Picher)—Expects to build mill on tract now being developed near Blue Bird mine, west of Tar River, Oklahoma.

WHITE (Picher)—Has given up active operation for summer. Continuous drilling.

### SOUTH DAKOTA

#### Lawrence County

CAPITAL GOLD (Deadwood)—Plans completed for beginning work on property adjoining Trojan company in Deadwood Gulch. Power line being extended to ground and complete compressor plant will be installed. Ores will be shipped to Trojan cyanide plant. P. A. Griswold, of Omaha, Neb., president. R. M. Harrot secretary and general manager.

#### Pennington County

EGYPTIAN (Keystone)—Miners working on 120 level in North Pope mine of Egyptian company have broken into shoot of high-grade ore. Impossible at present to determine width or extent of ore. Free gold can readily be seen throughout rock. Work being pushed. Property adjoins Holy Terror, which was noted for high-grade, and lies on strike of that vein.

MAYWOOD CHEMICAL (Keystone)—Formerly Standard Essence Co. Shipping 50 tons spodumene weekly to Maywood, New Jersey.

### TEXAS

#### Brazoria County

SEVERAL DEEP WELLS at West Columbia now being drilled: Crown Oil Co.'s No. 1 Sealy in rock at 3129 ft.; Harris Co.'s No. 1 Moody at 3232 ft.; Gulf Coast Oil Co.'s No. 1 Smith at 3547 ft.; Sun Co.'s No. 1 McGregor in dry sand at 3780 ft.; Gulf Production Co.'s No. 1 Hogg at 3147 ft. showed some oil with 80% water.

FREEPORT SULPHUR CO. (Freeport)—Large tonnage sulphur being shipped to French government via Galveston, where arrangements made with U. S. Railroad Administration for wharfage facilities. British steamer "Tregothnan" carried out first cargo, and British steamer "Tremayne," operating under charter from French government, passed Sand Key June 12 en route to Galveston for second cargo.

#### Concho County

RUSSELL WELL (Paint Rock)—This well, in wild-cat territory, 10 miles northwest of Paint Rock, was shot and is flowing by heads, although not yet entirely cleaned out. Promises to be good producer.

#### Dallas County

GULF PIPE LINE (Dallas)—Material ordered for 150-mile pipe line from Fort Worth to Burkburnett. Company subsidiary or Gulf Oil Corporation.

#### Glasscock County

CONTRACT FOR SIX WELLS near Garden City, let recently to Houston firm. Two to be drilled not later than middle of September.

#### Harris County

GULF COAST DEVELOPMENT (Humble)—No. 2 Rodgers at 1830 ft. and No. 5 Landslide at 630 ft., each a 10-bbl. pumper, brought in recently.

GULF PRODUCTION (Humble)—No. 5 Eyers, largest producer of field, brought in during second week in June, now making 1500 bbl. daily. During this week field produced over 10,000 bbl. per day.

#### Liberty County

HUMBLE OIL AND REFINING (Hull)—No. 1 Palmer brought in flowing 350 bbl.

TEXAS CO. (Hull)—Has temporarily abandoned No. 1 Fee at 3914 ft.

#### Nacogdoches County

MILLER OIL (Nacogdoches)—Operating for several months on Jose Maria Mora land grant 16 miles southeast of Nacogdoches, and now has six producing wells. Officials of company state many wells will now be drilled and refinery built.

#### Orange County

SEABOARD OIL AND REFINING (Orange)—Making tests and analyses on oil from Orange County field, with intention of extending pipe line to field if sufficient number of producing wells are brought in.

#### Runnels County

GULF PRODUCTION recently shot Russell well at 2300 ft. and brought in 300-bbl. producer. Well about 25 miles southwest of Coleman. Well demonstrates that Strawn sand, in which oil occurs, traverses Coleman County from northeast to southwest.

### UTAH

#### Beaver County

GOLD CROWN (Milford)—High-grade ore carrying gold, silver, lead, reported on 200 and 300 levels, and continuous between. Work suspended to install oil engine and two new compressors. Shaft down 200 ft.

MAJESTIC (Milford)—Owns Old Hickory and Hoosier Boy. Work to be resumed. Old Hickory has produced considerable copper ore running about 4 per cent.

#### Juab County

BIG HILL (Eureka)—To sink shaft; funds to be provided by increasing capitalization from 500,000 to 1,000,000 shares. New issue to be placed in treasury and stockholders given first chance to purchase. Jesse Knight president.

CHIEF CONSOLIDATED (Eureka)—New pumping equipment underground; consists of three units, each of 1000 gal. per minute capacity. Being installed on 600, 1200 and 1800 levels, where company is operating smaller pumps. Some of best ore mined recently coming from below 1800.

INDEPENDENCE (Eureka)—Recently organized company operating in east Tintic has purchased old Bullion Beck mill, at Eureka, and is tearing down to use timber for mine buildings. Has ordered equipment for shaft sinking.

PROVO MINING (Eureka)—Option given on property of 13 acres adjoining Tintic Standard on west at rate of 9c. a share on capitalization of $840,000, placing value of about $80,000 on property. Small cash payment made. Entire amount due in nine months. Sale made in preference to levying assessment for development.

TINTIC STANDARD (Eureka)—May production 78 cars, or about 4000 tons, and April, 92 cars. On completion of Goshen Valley R.R. by August, shipments to be increased. Old shaft to be retimbered and enlarged to 1000 ft. Considering mill for treatment of low-grade ores.

#### Salt Lake County

CARDIFF (Salt Lake City)—Truck has made first round trip up and down Big Cottonwood Canyon this season. New ore running high in silver; averages five to nine feet in width; followed about 200 feet.

#### Washington County

DIXIE (St. George)—Orebody shut off by cave-in occurring week ended June 7. May be necessary to sink 1200-ft. shaft, as believed not possible to clear out winze and retimber workings. Shipping 50 to 70 tons monthly of good-grade copper ore last two years.

### WASHINGTON

#### Okanogan County

OKANOGAN VALLEY POWER CO. officials expect to start work about Aug. 1 on first unit of power plant. Dam will be built on Similkameen River 3½ miles above Oroville, above falls 23 ft. high. Will be 350 ft. long, and 60 high. Expect to furnish power to mines in Oroville district.

APACHE (Nespelem)—Silver mine under working bond; 15 men employed. Owned by Biggs and Ostrowskie, of Nespelem.

GREAT METALS M. & M. (Nespelem)—Reworking old dump about three miles above Nespelem; 100-ton mill operating full capacity.

#### Stevens County

O-LO-LIM COPPER operating near Detillion Bridge on former Spokane Indian Reservation. Expects to resume shipping crude ore soon. May build mill if development warrants.

YOUNG AMERICA (Bossburg)—Machinery for mill in place, and experimental runs being made on ore from dump.

LOON LAKE COPPER (Loon Lake)—Putting mill in condition preparatory to resuming work.

NORTHERN LIGHT GROUP (Northport)—Development resumed under direction of C. C. Knutson.

### CANADA

#### British Columbia

CAMERON AND DALLAIRE are testing their gold-platinum placer on Government Creek, 40 miles south of Prince George.

PROSERPINE (Barkerville)—Tregillus, Carey, and Blair have resumed shaft sinking on Proserpine Mountain gold quartz vein.

ROCK CANDY (Grand Fork)—Consolidated M. and S. Co. pushing development of this fluorspar property. Mill bins full and plant ready for work. Spur between Kettle Valley Ry. and mill unfinished, but rails now on spot.

MOLLY GIBSON (Kitto Landing, B. C.)—Consolidated M. & S. Co. has resumed work on this property. Tramway damaged by snowslide restored.

SILVERSMITH MINES (Sandon)—Putting 100 tons of ore daily through new mill, which is running smoothly, concentration ratio being about 10 to 1. Expect to ship about five carloads of concentrates and crude ore monthly.

SOVEREIGN (Sandon)—Building tramway from mine to Sandon. Irwin White in charge of this Cunningham property. Ore will be treated at Alamo mill, now almost ready for operation.

WONDERFUL (Sandon)—Tramway completed, half mile long.

GOLD CURE (Slocan, B. C.)—Operating seven claims on south fork of Kaslo Creek. To resume operations about July 1. H. Park, general manager. Index and Silver Bell properties in same district both operating. Motor trucks used to haul ore to railroad, distance of eight miles.

#### Ontario

CATHERINE (Boston Creek)—Camp buildings completed and surface work being done.

CHARETTE (Boston Creek)—Steam-driven mine plant installed and shaft being sunk.

BOURKES (Bourke's Station)—Mine plant being installed. Construction of new mill of about 80-ton capacity will soon begin.

REEVES-DOBIE (Gowganda)—Installation of oil flotation equipment of about 100 tons daily capacity nearly completed.

FOUR NATIONS (Kenogami Lake)—Prospecting shaft being sunk on promising vein.

EAST KIRK (Kirkland Lake)—Camp buildings put up. Exploration and development plans made and mining plant will be installed.

LAKE SHORE (Kirkland Lake)—Owing to strike, pumps have been removed from mine, which is now flooded, management holding that dewatering later on will be cheaper than keeping pumps going.

GOLDFIELDS CONSOLIDATED (Larder Lake)—Contract let for extensive diamond drilling on Reddick property.

KENABEEK CONSOLIDATED (Montreal River District)—Arrangements made to resume work by new company known as Triangle Silver Mines, capitalized at $2,000,000.

SOVEREIGN (Porcupine)—Diamond drilling indicates orebody 8 ft. wide at 164 ft. depth.

### COLOMBIA

SOUTH AMERICAN GOLD AND PLATINUM CO. preparing to install additional equipment for mining by modern methods. Subsidiaries working platinum- and gold-bearing ground in Intendencia of El Choco. Recently disposed of 300,000 shares. Adolph Lewisohn, of New York, president.

### KOREA

ORIENTAL CONSOLIDATED (Unsan)—Suribong power plant cannot be started until end of rainy season, as turbines cannot be shipped from San Francisco before July 15. All excavation complete. Expect to finish dam with division walls early in July; also work on power house and draft tubes. Labor demonstrations seem over. Everything quiet at Unsan (written May 5), where Japanese infantry detachment is still stationed. Little rain during April.

### BURMA

BAWDWIN MINES (Bawdwin)—Burma Corporation, Ltd., reports—No. 3 level, east crosscut, 402 ft. north, from 0 to 25 ft., no value; from 25 to 30 ft., 5 oz. silver, 5% lead, 4½% zinc, 2% copper; No. 4 level, east crosscut, 501 ft. north, from 20 to 22 ft., 39 oz. silver, 2% lead, 2% zinc, 17% copper; from 22 to 24 ft. on north side, 55 oz. silver, no lead, 2% zinc, 24% copper; from 22 to 25 ft. on south side, 6 oz. silver, no lead, 1% zinc, 2% copper. Lead production for April 2,023 tons gross; refined lead 1,710 tons; and refined silver 209,000 oz.

# The Market Report

SILVER AND STERLING EXCHANGE

| June | Sterling Exchange | Silver New York, Cents | Silver London, Pence | June | Sterling Exchange | Silver New York, Cents | Silver London, Pence |
|---|---|---|---|---|---|---|---|
| 19 | 4.6144 | 112⅜ | 54⅜ | 23 | 4.6056 | 110⅛ | 53⅜ |
| 20 | 4.6063 | 111½ | 54⅛ | 24 | 4.5988 | 111⅛ | 54 1/16 |
| 21 | 4.6088 | 111¼ | 54 1/16 | 25 | 4.5900 | 110⅞ | 54 1/16 |

New York quotations are as reported by Handy & Harman and are in cents per troy ounce of bar silver, 999 fine. London quotations are in pence per troy ounce of sterling silver, 925 fine.

DAILY PRICES OF METALS IN NEW YORK

| June | Copper Electrolytic | Tin Spot. | Lead N. Y. | Lead St. L. | Zinc St. L. |
|---|---|---|---|---|---|
| 19 | 17.80 @17.85 | †72½ | 5.40 | 5.15 | 6.50 @6.60 |
| 20 | 17.85 @17.87½ | †72½ | 5.40 | 5.15 | 6.57½ @6.62½ |
| 21 | 17⅞ | †72½ | 5.40 | 5.15 | 6.65 @6.75 |
| 23 | 18.10 | 68 | 5.40 | 5.15 | 6.70 @6.80 |
| 24 | 18.15 @18.35 | 68 | 5.40 | 5.15 | 6.85 @6.90 |
| 25 | 18.15 @18.35 | 68 | 5.40 | 5.15 | 7.00 |

† Government price.

The above quotations are our appraisal of the average of the major markets based generally on sales as made and reported by producers and agencies, and represent to the best of our judgment the prevailing values of the metals for the deliveries constituting the major markets, reduced to basis of New York, cash, except where St. Louis is the normal basing point.

Quotations for copper are for ordinary forms of wire bars, ingot bars and cakes. For ingots an extra of 0.05c. per lb. is charged and there are other extras for other special shapes. Cathodes are sold at a discount of 0.125c. per lb.

Quotations for zinc are for ordinary Prime Western brands. We quote New York price at 35c. per 100 lb. above St. Louis.

LONDON

| June | Copper Standard Spot | Copper Standard 3 M. | Copper Electrolytic | Tin Spot | Tin 3 M. | Lead Spot | Lead 3 M. | Zinc Spot |
|---|---|---|---|---|---|---|---|---|
| 19 | 84⅛ | 85 | 86½ | 243 | 239 | 22⅞ | 22⅝ | 36½ |
| 20 | 86⅜ | 87¼ | 89 | 242½ | 239 | 22⅝ | 22½ | 37¼ |
| 21 | ... | ... | ... | ... | ... | ... | ... | ... |
| 23 | 86½ | 87½ | 89 | 239½ | 236 | 22½ | 22¼ | 37½ |
| 24 | 88 | 88½ | 90 | 240½ | 237 | 22½ | 22½ | 38¼ |
| 25 | 87½ | 88¼ | 90 | 242 | 241½ | 22 | 22½ | 38¼ |

The above table gives the closing quotations on London Metal Exchange. All prices are in pounds sterling per ton of 2240 lb.

## Metal Markets

**NEW YORK—June 25, 1919**

In both copper and zinc there were sharp rises, the advance in zinc being rather spectacular. In both cases the advances happened on relatively small business. Lead was quiet, but very firm.

The regular lines quote $18 per 2000 lb. for freight from New York to British ports, but terms as low as $15 may, perhaps, be obtained from outsiders. Rates to French ports also are easier. Much better terms are obtained from Galveston than from New York. The rate from Pacific ports to Hongkong and Kobe remains at $14.

The director of sales of the War Department reports the following metals on hand as of June 1: Soft pig lead, 3698 tons; antimonial pig lead, 472 tons; heavy sheet lead, 5000 tons; lead disks, 590 tons; lead calking wire, 613 tons; zinc, 38,000 tons; platinum, 20,000 oz.

**Copper**—Domestic sales were relatively light, and although there were some encouraging export sales to England and France, both through the Copper Producers' Association and outside of it, the quantity was not great. Nevertheless, even on small business producers had no difficulty in advancing their prices almost from day to day and meeting with prompt acceptance of the new terms. The advance in copper in England aided materially in this. In the latter part of the week producers were asking £93 in both France and England, which could be figured as netting 18½c., f.o.b., New York, on the British business, and a trifle less on the French. In the meanwhile, July copper for domestic consumption was to be had on the basis of 18.15c., New York, but during the last two days some fair business for July-August delivery was done at 18.35c. For August alone all producers would probably require that price.

The copper market, like other markets, is strong on sentiment, and at present small influences are sufficient to move it upward. A contributory factor in shaping opinion is the anticipation that there will be a strike in Butte in July which will result in the closing of the mines.

In the copper manufacturing districts of New York and New England a strike developed this week at Hastings-on-the-Hudson. On the other hand, the American Brass Co. yielded to its strikers, granting them an advance of 10c. per hour, which will probably compel the other concerns at Waterbury and Ansonia to do likewise, and will end the troubles at those places.

Copper-wire manufacturers report that business has become very good. The first demand was mainly for rods and bare wire, but now there is considerable demand for cables. The business is both for repair work and new construction, the latter being especially for extensions of existing lines. Some considerable export business has been done right along.

**Copper Sheets**—The base price of copper sheets is 24c. per lb. Copper wire is quoted at 20⅞@21c. in carload lots, f.o.b. mill.

**Tin**—The Government ban was lifted on June 23, and beginning with that day an open market, subject to the restrictions that we reported last week, began. Straits and electrolytic tin were immediately quoted at 70c., and common tin (99%) at 68c. However, the market has not yet found itself. It is believed that there are some important consumers who are greatly oversupplied, and that they will naturally dispose of their surplus and either take chances on the market later in the year or else cover themselves immediately by purchases of tin for shipment from points of origin. On June 24 contracts for July shipments from Singapore were made at 52c, and for July-August shipments from Batavia, at 51⅝c. Such operations will naturally bring the American market to its true level.

**Lead**—This metal was quiet, but very firm. The statistical position without doubt has experienced further improvement. Lead manufacturers report that business has become very good. In white lead there is an especially noteworthy activity.

There were some substantial sales of Mexican lead this week, both for Europe and to the Orient. There have been some unfavorable comments from Great Britain respecting the manner with which Mexican lead has been handled in that market.

**Zinc**—This market advanced sharply from day to day on what looked like speculative buying, but when the price approached 7c. consumers, including galvanizers, appeared to have become interested, and they made some purchases. The advance in the London market helped things along. Zinc at £39, London, which has practically been reached, is equivalent to 7c., St. Louis. Some export business has been done, and there is reason to anticipate that more will follow. High-grade zinc has not advanced in the same proportion as common zinc. Even in the latter part of the week it probably could still have been bought at 7⅛c., delivered in the East, which would indicate a premium of only about ¼c. per lb. over common zinc. Zinc dust has advanced even less. Prolong dust can probably still be bought at 9c., f.o.b., works.

The smelteries at Clarksburg and Meadowbrook, W. Va., are closed, owing to labor troubles.

The electrolytic plant of the River Smelting and Refining Co., at Keokuk, Iowa, has been closed, probably permanently.

**Zinc Sheets**—The quoted price of zinc sheets is $10 per 100 pounds.

## Other Metals

**Aluminum**—Virgin metal quoted at 32c. per lb. Market weaker.

**Antimony**—Quiet at 8⅞@8¼c., for spot. Futures were quoted at 8¼@8⅜, but very little is offered.

**Bismuth**—Metal of the highest purity for pharmaceutical use is quoted at $3.20 per lb. for wholesale lots—500 lb. and over.

**Cadmium**—Quoted at $1.50 per lb. in lots of 500 pounds. For lots under 200 pounds, $1.75 per lb.

**Nickel**—Ingot, 40c.; shot, 43c.; electrolytic, 45c. per pound.

**Quicksilver**—A further advance brought the market to $95. San Francisco telegraphs $92, strong.

## Silver and Platinum

**Silver**—Owing to the decline in exchange on London, as well as the fact that the China exchanges have weakened, the price of silver has not been maintained. The cession of Shantung to Japan has caused more or less disturbance, and trade has quieted down for a time.

Mexican dollars at New York: June 19, 87; June 20, 86; June 21, 85⅞; June 23, 85; June 24, 85½; June 25, 85⅜.

**Platinum**—Refined ingot, $105@107½.

**Palladium**—Strong at $120.

## Zinc and Lead Ore Markets

**Joplin, Mo., June 21.**—Blende, per ton, high, $45.10; basis 70 per cent zinc, premium, $43; Prime Western, $42; Sludge and flotation, $41@37; calamine, basis 40 per cent zinc, $25@22. Average settling prices: Blende, $40; calamine, $23.83; all zinc ores, 39,78.

Lead, high, $62.15; basis 80% lead, $60; average settling price, all grades of lead, $59.13 per ton.

Shipments the week: Blende, 9,789; calamine, 284; lead, 1,295 tons. Value, all ores the week, $477,580.

Men are leaving the mining field at the rate of 100 a day. All are not miners, but many are, and the result is noticeable in reduced ore production. The mine owners failed to agree on a general close down during the harvest, but so many of the miners are leaving that all mines in operation are seriously handicapped, and several mills have been forced to close down. The output is estimated reduced 20 per cent.

**Platteville, Wis., June 21**—Blende, basis 60 per cent zinc, $45 base for premium grade, and $42.50 base for high lead or Prime Western grade. Lead ore, basis 80% lead, $59 base for top grade and $56 to $58 for second grade. Shipments reported for the week are 2,012 tons blende, 79 tons galena, and 378 tons sulphur ore. For the year to date the totals are 48,319 tons blende, 2,327 tons galena, and 6,748 tons sulphur ore. During the week 2,250 tons blende was shipped to separating plants.

## Other Ores

**Molybdenite**—Quoted nominally at 75@85c. per lb.

**Tungsten Ore**—Some business in off-grade ore was reported at $7@7½. High-grade ore is held at much higher prices, but buyers are unwilling to meet the views of sellers.

**Pyrites**—Spanish pyrites is quoted at 19c. per unit for furnace ore, c.i.f., New York or other Atlantic port. Gradual reduction in ocean freights.

## Iron Trade Review

**PITTSBURGH—June 24**

The signing of the peace treaty by Germany will probably release promptly a

great many construction jobs, held back as a matter of judgment or of principle until the treaty should actually be signed. It is the opinion of the steel trade that a great deal of investment work will be undertaken. Hitherto the demand for steel has been chiefly for ordinary current consumption, and this demand has been larger than would have been expected from such quarters. It is not true, however, as suggested, that there has been no demand for steel for construction purposes. The monthly reports of the Bridge Builders' and Structural Society show that twice as much fabricated steel was let in May as in April. The monthly reports of bookings of fabricated steel jobs, in proportion to capacity of the fabricating shops, have been as follows: January, 12%; February, 12½%; March, 17½%; April, 24½%; May, 49%.

Though official announcement has not been made, it is known to the steel trade that the Railroad Administration has decided to buy 300,000 tons of rails, following the 200,000 tons recently purchased with a protest as to the price paid. It is understood that this time there will be no protest, as the Mar. 21 steel prices have justified themselves by holding and by developing a widespread demand.

There has been further slight increase in the volume of buying of most finished-steel products.

Last night at Atlantic City the union sheet and tin mills came to an agreement with the Amalgamated Association, which controls considerably less than half the total, on scales for the twelvemonth beginning July 1. The union receded from the extreme demands that had been formulated, including a 25% increase in base rates, and the establishment of four turns instead of three turns per day, and accepted 10% and 6 advances for certain members of the crews, chiefly the less well paid, whereby the average of scale rates, which are per ton of output, is increased 3.6% for sheet mills and 2.6% for tin mills.

**Pig Iron**—The local market, which had not been as active as markets in various other districts, has quieted down, but the furnaces in blast are well provided with orders, and the market is steady if not strong. There is still less competition from outside districts, the Valley furnaces having more of a hold in this territory than formerly. Valley prices, which may perhaps be shaded sometimes, remain: Bessemer, $27.95; basic, $25.75; foundry, $26.75; forge, $25.75, at furnace, with $1.40 freight to Pittsburgh. Some furnaces with less freight to Pittsburgh are giving buyers the freight advantage.

**Steel**—Producers still complain that billets are too low at $38.50, the Mar. 21 price, by comparison with finished products, and with sheet bars at $42 and slabs at $41, and do not seem anxious to sell, but at the same time there is scarcely any demand. Sheet-bar orders are being placed freely from week to week, according to the requirements of sheet mills, but there is scarcely any buying ahead. Slabs have been quiet, but there is now an inquiry from the National Pressed Steel Co., Massillon, Ohio, for 10,000 tons for delivery over three months, to be used in rolling "steel lumber," a sort of H-beam section in which the company is building up a trade.

**Ferromanganese**—Reports that domestic producers have made sales at $120 to $125, delivered, for 80% ferromanganese, are probably premature, and the market may be quoted at $110@115 on the basis of former transactions in resale material. The English asking price continues at $125, delivered. Spiegeleisen is nominal at $33@35, delivered, for 18%.

**Coke**—Sales of second-half furnace coke by the Oliver & Snyder Steel Co., reported last week at 32,000 to 33,000 tons, have now been increased to about 50,000 tons, which is all this interest desires to sell. Nearly all contracts are on the ratio basis of the price of a net ton of coke at ovens, being 16c. to each dollar in the price of basic pig iron at Valley furnaces; in other words, a ratio of 6¼ to 1, making coke $4.12 when pig iron is $25.75. Only a relatively small part of the possible output can be sold, by reason of so many furnaces being out of blast, and in the last two years many furnaces have established byproduct ovens. Some of the Eastern furnaces formerly using Connellsville coke are likely to purchase byproduct coke, Bethlehem being a seller, and the Rainey-Wood and Midvale interests are about to start byproduct plants, part of the output being offered in the market. There has been fairly free contracting in foundry coke for second half, generally at $5@5.50. Spot coke is $4 for furnace and $4.50@$5 for foundry, per net ton at ovens.

## MONTHLY AVERAGE PRICES OF METALS

### Silver

| | New York | | | London | | |
|---|---|---|---|---|---|---|
| | 1917 | 1918 | 1919 | 1917 | 1918 | 1919 |
| Jan. | 75.630 | 88.702 | 101.125 | 36.682 | 44.356 | 48.438 |
| Feb. | 77.585 | 85.716 | 101.125 | 37.742 | 42.792 | 48.027 |
| Mar. | 73.861 | 88.082 | 101.125 | 36.410 | 43.620 | 48.171 |
| April | 73.875 | 95.346 | 101.125 | 36.963 | 47.215 | 48.886 |
| May | 74.745 | 99.505 | 107.135 | 37.940 | 48.980 | 52.104 |
| June | 76.971 | 99.500 | ..... | 39.065 | 48.875 | ..... |
| July | 79.010 | 99.625 | ..... | 40.110 | 48.813 | ..... |
| Aug. | 85.407 | 100.292 | ..... | 43.418 | 49.077 | ..... |
| Sept. | 100.740 | 101.125 | ..... | 50.920 | 49.500 | ..... |
| Oct. | 87.332 | 101.125 | ..... | 44.324 | 49.500 | ..... |
| Nov. | 85.891 | 101.125 | ..... | 43.584 | 48.969 | ..... |
| Dec. | 85.960 | 101.125 | ..... | 43.052 | 48.492 | ..... |
| Year | 81.417 | 96.772 | ..... | 40.851 | 47.516 | ..... |

New York quotations cents per ounce troy, 999 fine London, pence per ounce, sterling silver, 925 fine.

### Copper

| | New York | | London | | | |
|---|---|---|---|---|---|---|
| | Electrolytic | | Standard | | Electrolytic | |
| | 1918 | 1919 | 1918 | 1919 | 1918 | 1919 |
| Jan. | 23.500 | (a) | 110.000 | 92.238 | 125.000 | 106.619 |
| Feb. | 23.500 | 16.763 | 110.000 | 78.700 | 125.000 | 95.700 |
| Mar. | 23.500 | 14.856 | 110.000 | 76.821 | 125.000 | 82.071 |
| April | 23.500 | 15.246 | 110.000 | 77.300 | 125.000 | 82.200 |
| May | 23.500 | 15.864 | 110.000 | 77.767 | 125.000 | 81.227 |
| June | 23.500 | ..... | 110.000 | ..... | 125.000 | ..... |
| July | 25.904 | ..... | 119.913 | ..... | 134.913 | ..... |
| Aug. | 26.000 | ..... | 122.000 | ..... | 137.000 | ..... |
| Sept. | 26.000 | ..... | 122.000 | ..... | 137.000 | ..... |
| Oct. | 26.000 | ..... | 122.000 | ..... | 137.000 | ..... |
| Nov. | 26.000 | ..... | 122.000 | ..... | 137.000 | ..... |
| Dec. | (a) | ..... | 118.447 | ..... | 133.167 | ..... |
| Year | 24.628 | ..... | 115.530 | ..... | 130.507 | ..... |

(a) No Market.

### Tin

| | New York | | London | |
|---|---|---|---|---|
| | 1918 | 1919 | 1918 | 1919 |
| January | 85.500 | 67.702 | 293.227 | 248.557 |
| February | 92.000 | 66.801 | 311.525 | 223.963 |
| March | (a) | 67.934 | 318.875 | 236.843 |
| April | (a) | 72.500 | 329.905 | 225.275 |
| May | (a) | 72.500 | 364.217 | 234.398 |
| June | (a) | ..... | 331.925 | ..... |
| July | (a) | ..... | 360.347 | ..... |
| August | (a) | ..... | 380.900 | ..... |
| September | (a) | ..... | 343.905 | ..... |
| October | (a) | ..... | 335.543 | ..... |
| November | (a) | ..... | 323.550 | ..... |
| December | (a) | ..... | 267.736 | ..... |
| Av. year | (a) | ..... | 330.138 | ..... |

(a) No average computed.

### Lead

| | New York | | St. Louis | | London | |
|---|---|---|---|---|---|---|
| | 1918 | 1919 | 1918 | 1919 | 1918 | 1919 |
| January | 6.782 | 5.432 | 6.684 | 5.316 | 29.00 | 37.227 |
| February | 6.973 | 5.057 | 6.899 | 4.784 | 29.00 | 28.675 |
| March | 7.201 | 5.226 | 7.091 | 4.992 | 29.00 | 27.952 |
| April | 6.772 | 4.982 | 6.701 | 4.722 | 29.00 | 24.888 |
| May | 6.218 | 5.018 | 6.704 | 4.773 | 29.00 | 23.852 |
| June | 7.611 | ..... | 7.511 | ..... | 29.00 | ..... |
| July | 8.033 | ..... | 7.750 | ..... | 29.00 | ..... |
| August | 8.050 | ..... | 7.750 | ..... | 29.00 | ..... |
| September | 8.050 | ..... | 7.750 | ..... | 29.00 | ..... |
| October | 8.050 | ..... | 7.750 | ..... | 29.00 | ..... |
| November | 8.050 | ..... | 7.750 | ..... | 31.20 | ..... |
| December | 6.564 | ..... | 6.324 | ..... | 40.00 | ..... |
| Year | 7.413 | ..... | 7.222 | ..... | 30.10 | ..... |

### Zinc

| | New York | | St. Louis | | London | |
|---|---|---|---|---|---|---|
| | 1918 | 1919 | 1918 | 1919 | 1918 | 1919 |
| January | 7.836 | 7.272 | 7.661 | 7.922 | 54.000 | 56.045 |
| February | 7.814 | 6.623 | 7.639 | 6.273 | 54.000 | 46.150 |
| March | 7.461 | 6.500 | 7.286 | 6.150 | 54.000 | 38.500 |
| April | 6.890 | 6.465 | 6.715 | 6.114 | 54.000 | 36.118 |
| May | 7.314 | 6.429 | 7.114 | 6.079 | 54.000 | 35.477 |
| June | 8.021 | ..... | 7.791 | ..... | 54.000 | ..... |
| July | 8.688 | ..... | 8.338 | ..... | 54.000 | ..... |
| August | 8.985 | ..... | 8.635 | ..... | 54.000 | ..... |
| September | 9.442 | ..... | 9.092 | ..... | 54.000 | ..... |
| October | 8.801 | ..... | 8.451 | ..... | 54.000 | ..... |
| November | 8.491 | ..... | 8.141 | ..... | 54.100 | ..... |
| December | 8.163 | ..... | 7.813 | ..... | 56.050 | ..... |
| Year | 8.150 | ..... | 7.820 | ..... | 54.180 | ..... |

New York and St. Louis quotations, cents per pound. London, pounds sterling per long ton.

### Pig Iron, Pittsburgh

| | Bessemer‡ | | Basic‡ | | No. 2 Foundry | |
|---|---|---|---|---|---|---|
| | 1918 | 1919 | 1918 | 1919 | 1918 | 1919 |
| January | $37.25 | $33.60 | $33.95 | $31.40 | $33.95 | $32.40 |
| February | 37.25 | 33.60 | 33.95 | 31.40 | 33.95 | 32.40 |
| March | 37.25 | 32.54 | 33.95 | 31.40 | 33.95 | 29.12 |
| April | 36.15 | 29.35 | 32.95 | 27.15 | 33.95 | 28.15 |
| May | 36.20 | 29.35 | 33.00 | 27.15 | 34.00 | 28.15 |
| June | 36.36 | ..... | 33.16 | ..... | 34.16 | ..... |
| July | 36.60 | ..... | 33.40 | ..... | 34.40 | ..... |
| August | 36.60 | ..... | 33.40 | ..... | 34.40 | ..... |
| September | 36.60 | ..... | 33.40 | ..... | 34.40 | ..... |
| October | 36.60 | ..... | 34.40 | ..... | 35.40 | ..... |
| November | 36.60 | ..... | 34.40 | ..... | 35.40 | ..... |
| December | 36.60 | ..... | 34.40 | ..... | 35.40 | ..... |
| Year | $36.67 | ..... | $33.70 | ..... | $34.45 | ..... |

‡ As reported by W. P. Snyder & Co.

## STOCK QUOTATIONS

| N. Y. Exch.† | June 24 |
|---|---|
| Alaska Gold M. | 3 |
| Alaska Juneau | 2½ |
| Am.Sm.&Ref.,com. | 80½ |
| Am.Sm. & Ref., pf. | 107 |
| Am.Sm.Sec., pf., A | 95 |
| Am. Zinc | 22 |
| Am. Zinc, pf. | 58½ |
| Anaconda | 71½ |
| Batopilas Min. | 1½ |
| Bethlehem Steel | 85½ |
| Butte & Superior | 27 |
| Butte Cop. & Zinc | 12½ |
| Cerro de Pasco | 53½ |
| Chile Cop. | 25½ |
| Chino | 44½ |
| Colo. Fuel & Iron | 47 |
| Crucible Steel | 90½ |
| Crucible Steel, pf. | 100½ |
| Dome Mines | 13½ |
| Federal M. & S. | 14½ |
| Federal M. & S., pf. | 41 |
| Great Nor., ore ctf. | 45½ |
| Greene Cananea | 43 |
| Gulf States Steel | 65½ |
| Homestake | 85 |
| Inspiration Con. | 60½ |
| International Nickel | 31½ |
| Kennecott | 39½ |
| Lackawanna Steel | 82 |
| Mexican Petrol. | 181½ |
| Miami Copper | 27½ |
| Nat'l Lead, com. | 77 |
| National Lead, pf. | 109 |
| Nev. Consol. | 19 |
| Ontario Min. | 8 |
| Ray Con. | 23½ |
| Republic I.&S.,com. | 88½ |
| Republic I.&S., pf. | 104 |
| St. Joseph Lead | 13½ |
| Sloss-Sheffield | 66½ |
| Tennessee C. & C. | 124 |
| U. S. Steel, com. | 106½ |
| U. S. Steel, pf. | 116½ |
| Utah Copper | 86½ |
| Va. Iron C. & C. | 66 |
| Worthington Pump | 77½ |

| Boston Curb* | June 24 |
|---|---|
| Boston Ely | 1½ |
| Boston & Mont. | 84 |
| Butte & Lon'n Dev. | .20 |
| Calaveras | 1½ |
| Chief Con. | 3½ |
| Contact | ‡.05 |
| Cortez | .15 |
| Crown Reserve | .25 |
| Crystal Cop | 13 |
| Eagle & Blue Bell | 2½ |
| First Nat. Cop. | 1½ |
| Gadsden Cop. | 3½ |
| Houghton Copper | 1½ |
| Intermountain | ‡.05 |
| Iron Blossom | .40 |
| Iron Cap | 10½ |
| Majestic | .22 |
| Mexican Metals | .15 |
| Mines of America | ‡.05 |
| Mojave Tungsten | .15 |
| Nat. Zinc & Lead | .10 |
| Nevada-Douglas | .16 |
| New Baltic | 1½ |
| Oneco | .75 |
| Pacific Mines | ‡.35 |
| Rex Cons. | ‡.14 |
| Yukon Gold | .80 |

| San Fran.* | June 24 |
|---|---|
| Alta | ‡.08 |
| Andes | .20 |
| Best & Belcher | .13 |
| Caledonia | .15 |
| Challenge Con. | ‡.03 |
| Confidence | ‡.25 |
| Con. Virginia | 1.35 |
| Gould & Curry | .05 |
| Hale & Norcross | .19 |
| Jacket-Cr. Pt. | .03 |
| Mexican | .35 |
| Occidental | ‡.40 |
| Ophir | 1.00 |
| Overman | ‡.10 |
| Savage | .15 |
| Sierra Nevada | .05 |
| Union Con. | .17 |
| Utah Con. | ‡.04 |
| Belmont | 3.50 |
| Jim Butler | .38 |
| MacNamara | .76 |
| Midway | .37 |
| Mcnt.-Tonopah | ‡.20 |
| North Star | .09 |
| Rescue Eula | .20 |
| West End Con. | 1.70 |
| Atlanta | .04 |
| Booth | .09 |
| Comb. Frac. | .04 |
| Florence | .51 |
| Jumbo Extension | .11 |
| Kewanas | .03 |
| Nevada Hills | .04 |
| Nevada Packard | .23 |
| Round Mountain | .30 |
| Silver Pick | .06 |
| White Caps | .18 |

| Colo. Springs* | June 24 |
|---|---|
| Cresson Con. | 4.00 |
| Doctor Jack Pot | .03½ |
| Elkton Con. | .04½ |
| El Paso | .15 |
| Gold Sovereign | ‡.02 |
| Golden Cycle | 1.67 |
| Granite | .12 |
| Isabella | .04½ |
| Mary McKinney | .07½ |
| Portland | .95 |
| United Gold M. | .16½ |
| Vindicator | .40 |

| Boston Exch.† | June 24 |
|---|---|
| Adventure | ‡1½ |
| Ahmeek | 79½ |
| Algomah | ‡.80 |
| Allouez | 41 |
| Ariz. Com. | 14 |
| Arnold | ‡.20 |
| Bingham Mines | ‡9½ |
| Bonanza | ‡.20 |
| Butte-Balaklava | .38 |
| Calumet & Ariz. | 67½ |
| Calumet & Hecla | 410 |
| Carson Hill | ‡15 |
| Centennial | ‡16 |
| Copper Range | 50½ |
| Daly West | ‡2½ |
| Davis-Daly | 7½ |
| East Butte | 14½ |
| Franklin | 4 |
| Granby | ‡76½ |
| Hancock | 6 |
| Hedley | ‡12 |
| Helvetia | 5 |
| Indiana | ‡11½ |
| Isle Royale | 34½ |
| Keweenaw | 1½ |
| Lake | 4½ |
| La Salle | ‡3½ |
| Mason Valley | ‡3½ |
| Mass | 7 |
| Mayflower | 9½ |
| Michigan | 6½ |
| Mohawk | 66½ |
| New Arcadian | 14 |
| New Cornelia | 23½ |
| New Idria | 8 |
| Nipissing | 11½ |
| North Butte | 13½ |
| North Lake | ‡1½ |
| Oilbway | ‡2½ |
| Old Dominion | 41 |
| Osceola | 55 |
| Quincy | 68½ |
| St. Mary's M. L. | 59 |
| Santa Fe | ‡.35 |
| Seneca | 24 |
| Shannon | 3½ |
| Shattuck-Ariz. | ‡15½ |
| So. Lake | ‡3 |
| So. Utah | .23 |
| Superior | 8 |
| Superior & Bost. | 3½ |
| Trinity | 3½ |
| Tuolumne | 1¼ |
| U. S. Smelting | 67 |
| U. S. Smelting, pf. | 50 |
| Utah Apex | 13 |
| Utah Con. | 10½ |
| Utah Metal | 2½ |
| Victoria | 3½ |
| Winona | 1½ |
| Wolverine | 21 |

| N. Y. Curb† | June 24 |
|---|---|
| Alaska Mines | ‡½ |
| Big Ledge | ‡ |
| Butte & N. Y. | ‡ |
| Butte Detroit | ‡.03 |
| Caledonia | .41 |
| Calumet & Jerome | ‡½ |
| Can. Cop. Corpn | 1¼ |
| Cashboy | .08½ |
| Con. Ariz. Sm. | ‡ |
| Con. Coppermines | 7½ |
| El Salvador | 4 |
| Goldfield Con. | .16 |
| Goldfield Merger | .04 |
| Hecla Min. | 5½ |
| Howe Sound | ‡4½ |
| Jerome Verde | ‡½ |
| Louisiana | ‡ |
| Magma | ‡37½ |
| Marsh | .07½ |
| McKinley-Dar-Sa. | .63 |
| Milford | ‡.75 |
| Mother Lode | .43 |
| Nixon Nevada | .23 |
| Ohio Cop. | ‡ |
| Rawley | ‡2½ |
| Ray Hercules | 2½ |
| Richmond | ‡.50 |
| Rochester Mines | .19 |
| So. Am. G. & P. | 11½ |
| Standard S. L. | ‡ |
| Stewart | .26 |
| Success | .04½ |
| Tonopah | ‡½ |
| Tonopah Divide | .8 |
| Tonopah Ex. | 2½ |
| Tribullion | ‡.25 |
| Troy Arizona | ‡.10 |
| United Eastern | 4½ |
| United Verde Ext. | ‡40½ |
| United Zinc | ‡.25 |
| Utica Mines | ‡.08 |

| Toronto* | June 24 |
|---|---|
| Adanac | .15 |
| Bailey | .03 |
| Beaver Con. | .42 |
| Contagas | 1.37½ |
| Hargraves | .02 |
| Kerr Lake | 5.75 |
| La Rose | 31½ |
| Lake Shore | ‡1.00 |
| Min. Corp. of Can. | 2.50 |
| Peterson Lake | .09 |
| Teck-Hughes | .20 |
| Temiskaming | .37 |
| Trethewey | .37 |
| Wettlaufer-Lor. | .03 |
| Davidson | ‡.68 |
| Dome Exten. | .32 |
| Dome Lake | .18 |
| Hollinger | 6.50 |
| McIntyre | 1.62½ |
| Newray | .12½ |
| Porcu. Crown | .27 |
| Vipond | .20 |
| West Dome | .12 |

*Bid prices. † Closing prices. ‡ Last quotations.

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H. C. PARMELEE, *Acting Editor* WALTER RENTON INGALLS, *Consulting Editor*

MILLING NUMBER

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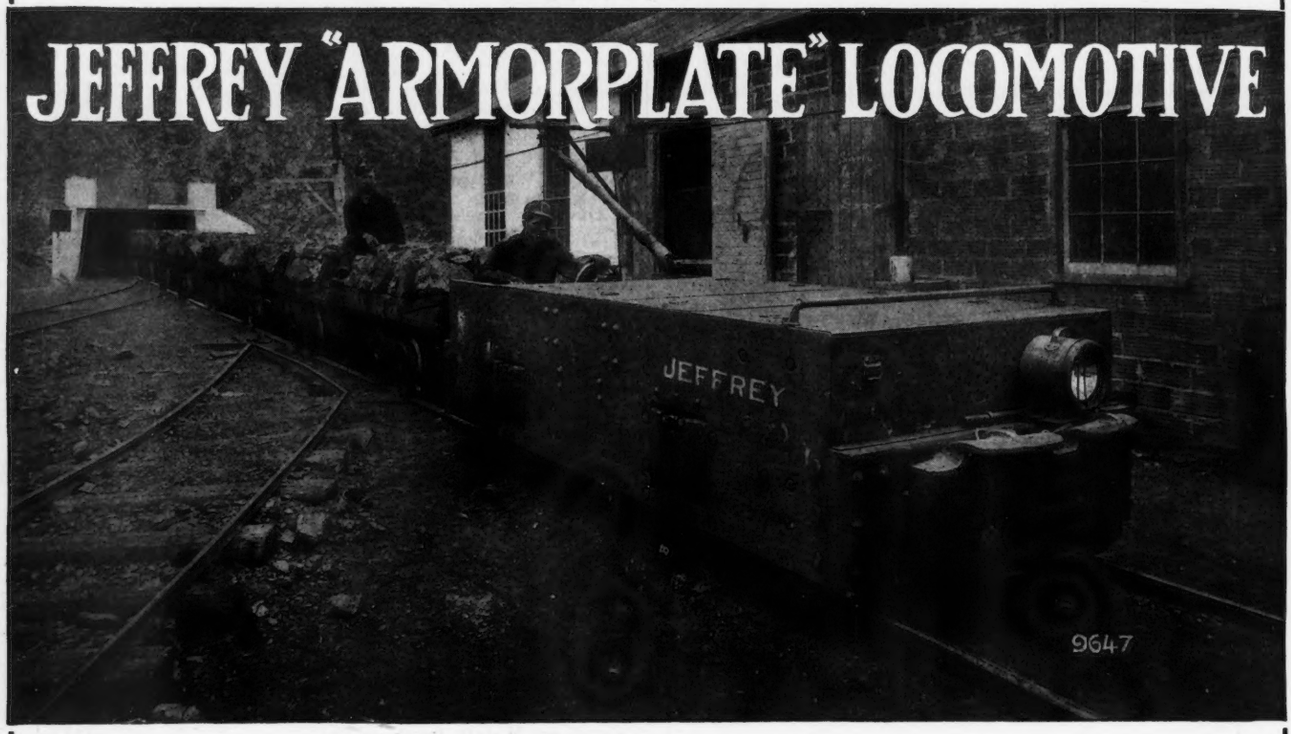
# Bigger Profits With Jeffrey Locomotives

UP-TO-DATE haulage will go far toward boosting production and lowering operating costs. Mules are too costly and too scarce to be depended upon.




## The Jeffrey Armorplate Type Locomotive

as illustrated above, is synonymous with maximum and continuous haulage service.

The fact that the leading operations of the country have selected this type as the standard for Main Haulage Service after investigating all other makes, is convincing evidence that they do all we claim for them.

We build both trolley and storage Battery Types for Gathering and Main Haulage purposes—and our engineers will gladly assist you in selecting the most economical haulage system for your requirements.

Let us tell you more about electrical and mechanical features of Jeffrey Locomotives that will appeal to mining men, such including Armorplate Type Frames, Heavy capacity Ball Bearing Motors, Improved Controller; Controller Arcmaster and Solenoid Switch; new style Journal Box for inside wheel type locomotives, and many others.

*Send for Catalogs*

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1. *Higher extraction.*
2. *Higher grade concentrate.*
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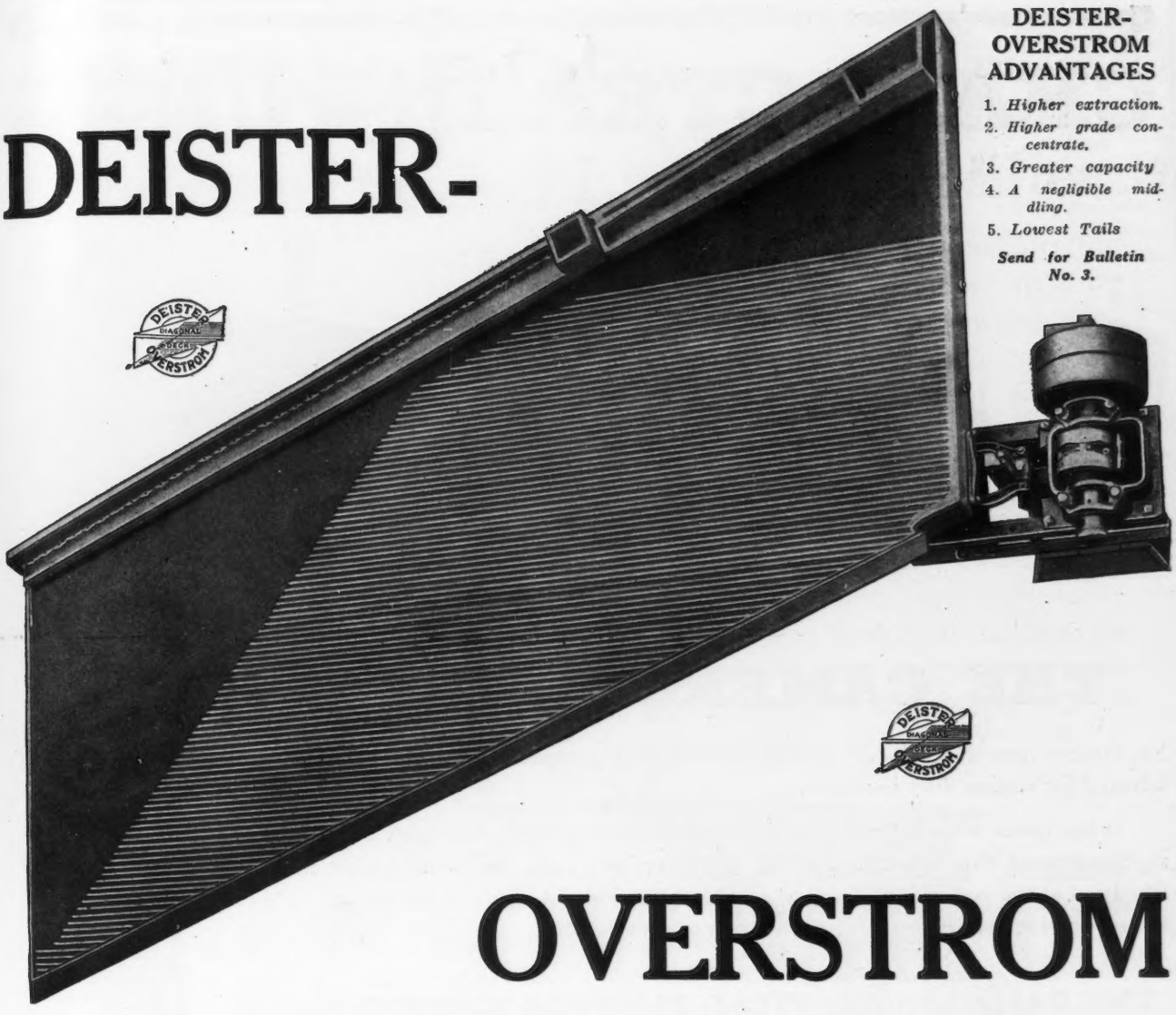
4. *A negligible middling.*
5. *Lowest Tails*

***Send for Bulletin No. 3.***

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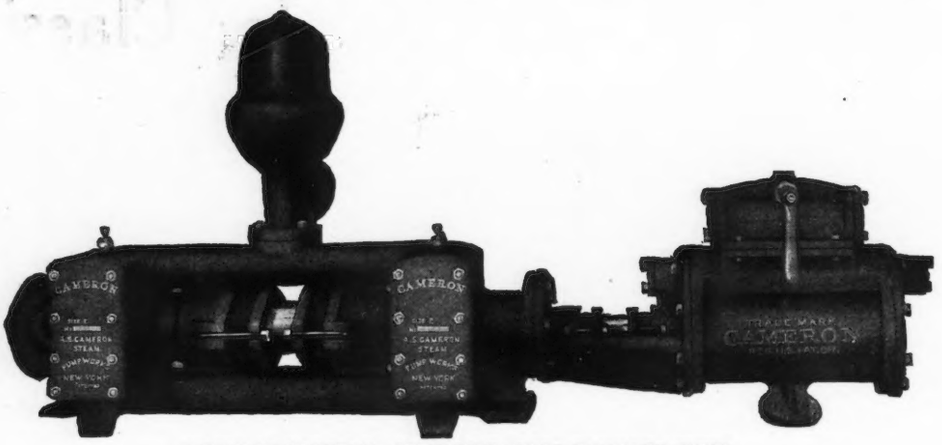


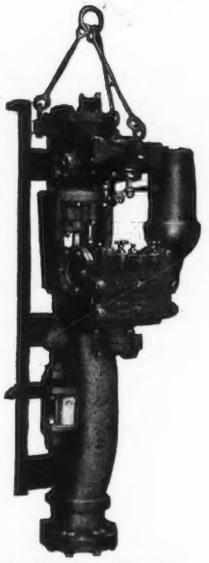

REGULAR PATTERN—OUTSIDE PACKED PLUNGER PUMP

Built for Service and Long Life,

## THE CAMERON STEAM PUMP

has made a record worthy of consideration by any prospective user of pumping equipment. Especially adapted for station duty in mines.

It has fewer working parts than any other steam pump. Compact in design and so constructed that while under full pressure of steam, the suction pipe may be lifted out of the water and pump allowed to race, without injury to the pump. There are no outside gear or working parts, rods or crossheads.



STANDARD SINKER

### THE CAMERON VERTICAL PLUNGER SINKING PUMP

is the recognized standard steam sinking pump of the mining world.

Strongly built and free from outside gear, arms or levers, it cannot be injured by collisions with the walls of the mine shaft. It is certain in operation and will work in any position.

Designed to handle gritty water. Easily and quickly packed from the outside.

Full line of repairs for immediate shipment, carried in Denver.

We would like to send you literature on the CAMERON line, and our monthly H & B BULLETIN if you mention it.

We are also Agents for Electrical Station and Sinking Pumps.

# THE HENDRIE & BOLTHOFF

## MANUFACTURING AND SUPPLY CO.

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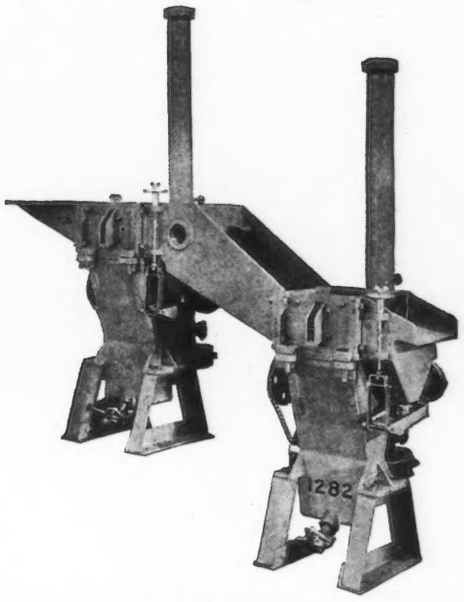
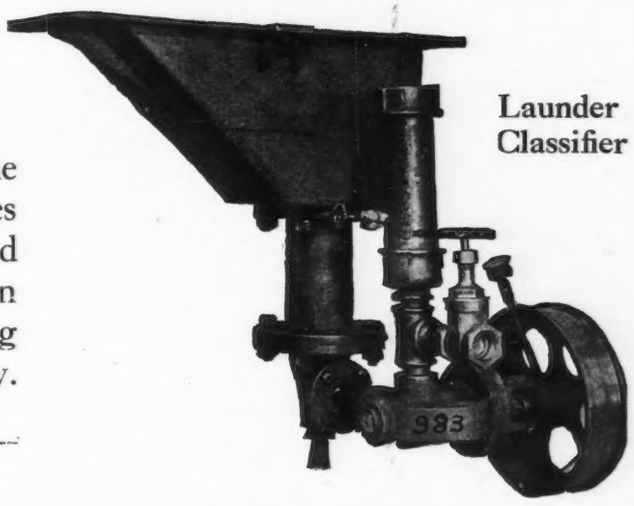
# RICHARDS
## Pulsator Jig and Launder Classifier




This Richards Pulsator Jig Unit saves 72% of Tungsten Concentrate assaying over 60% $WO_3$ at the Vasco Mill, Tungsten, Colorado.

Two high capacity concentrating and classifying devices utilizing the Richards pulsating-water sorting principle. These machines are compact—economical of power—and require a minimum of attention.

With *Richards Pulsator Jig* the freedom of movement for mineral and gangue particles due to the loose pulp bed assures high concentrating efficiency and rapid sorting, the pulsating water current prevents screen clogging and greatly reduces screen wear.




Launder Classifier

In *Richards Pulsator Classifier* the hindered settling principle gives you a perfect graded table feed and unusually high size ratio between the ore and gangue particles—a big factor for increased table efficiency.

*Let us send you some bulletins—write.*

# THE DENVER ENGINEERING WORKS CO.

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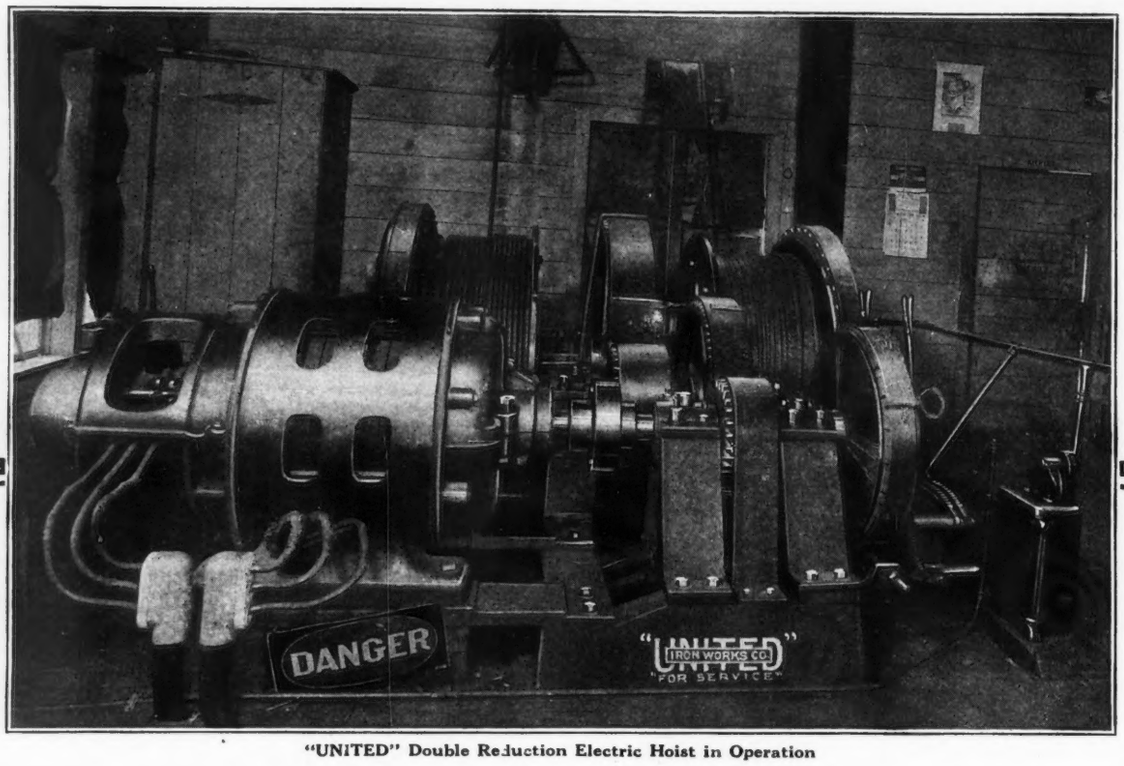



"UNITED" Double Reduction Electric Hoist in Operation

# *Mr. Hill Sold Us This Space—*

Mr. Hill, of the McGraw-Hill Publishing Company, sold us this space and twenty-five more of our ads will follow.

Well he didn't exactly sell to us, for buying advertising space in the Engineering and Mining Journal is something like buying a "Red Edge" shovel, Duxbak Belting, G. E. Motors or a coke, and any of the other well-established articles, because you know what you are getting pretty much in advance.

Anyhow, Mr. Hill told us that he thought that if we would tell the readers of this journal something about the many products that we manufacture, that we could extend their sale into many of the territories that we have not been heretofore serving, and when he showed us the class of readers, we believed him—so we are trying it.

**Also—**
**Cars,**
**Car Wheels,**
**Screens,**
**Crushers,**
**Rolls,**
**Tables,**
**Pig Irons,**
**Pumps,**
**Refrigerating Mchy., Etc.**

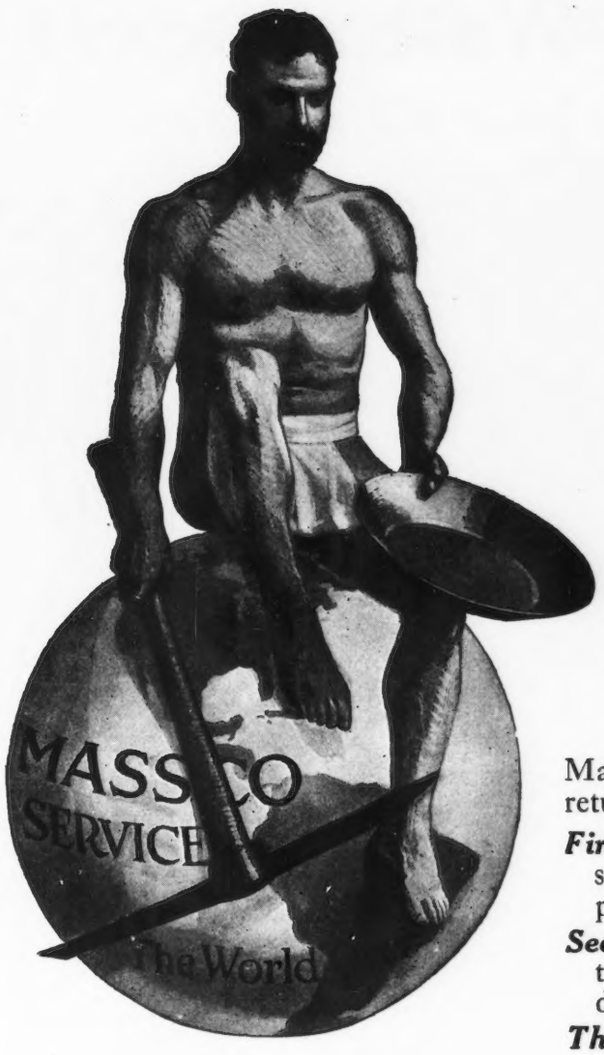
Now we have been manufacturing mining machinery for a number of years and have probably sold more equipment of this class in our territory than any other one manufacturer, and we have grown from one small plant to seven large plants, because of the reliability of "United" equipment, and because of our broadminded policy.

The hoist shown above represents an exact installation of "United" double drum, double reduction, geared electric hoist, used for skip hoisting in the Athletic Mine, near Webb City, Missouri. It has been in continuous operation for over two years now and has not had to be shut down one single time for repairs or any other trouble. Not even the brake blocks have had to be replaced. Its speed is 650-ft. per minute and the rope pull is 5,000-lbs. on unbalanced load.

***We Would Like to Have Your Inquiries on Hoists—Steam, Electric, Belted, First Motion, Any Kind. Send for Catalog 19.***

## UNITED IRON WORKS CO.

**General Offices, KANSAS CITY, MO.**




# Successful Purchasing

Massco Service offers to you a three-fold return for every dollar expended:

***First***—Standardized, time-tested mine supplies—the commodity you buy—at prices that are right and fair to you.

***Second***—The Experience of experts thoroughly familiar with every latest development in the mining field.

***Third***—The Service of an organization covering every phase of mining, milling, smelting and chemical industry.

The Massco line includes supplies which are recognized as standard the world over—backed by the Massco reputation for square dealing and fair prices. The line comprises everything needed for mining and milling mineral products.

Massco Service is available to you in any part of the world—put your equipment and supply problems "up to" Massco Engineers. Write for "Successful Purchasing," the booklet of buying economy.

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The sheave that caps your head-frame—the deepest sinking pump—the compressor that furnishes air to your drills and the engine which runs it—pipes for the air lines—the hoist, cables, cars, skips or cages—your men's cap-lamps, and their drills and shovels—all these are found in the Massco line.

Assay and laboratory equipment, machine tools, electrical supplies, mill equipment, power transmission machinery, supplies of every kind for mine, mill and smelter are listed in one of the Massco bulletins.

**THE MINE AND SMELTER SUPPLY COMPANY**

**A SERVICE STATION WITHIN REACH OF YOU**

**DENVER** **SALT LAKE CITY** **EL PASO**

**NEW YORK OFFICE: 42 Broadway**

# Sullivan New Water Stopers

## *Wet Down the Dust—Don't Wet the Runner*

Sullivan Rotating Water Stoper, "DT-42" with Reverse Feed and Brake.

Sullivan Water Stopers lay the dust at the back of the drill hole as fast as it is made.

The water tube carries the water into the hollow drill steel, surrounded by an air jet which acts as a seal and prevents leakage.

A single throttle controls both air, water and feed, and discharges an air blast through the steel before the water is turned on and after it is turned off. This keeps water from entering the front end of the drill cylinder when stopping work.

Two water stopers are available: (1) A light, hand rotated machine, "DT-44" (2) A self-rotator, with reverse feed and brake, "DT-42."

Sullivan Water Stopers are a proved success. Runners are enthusiastic, because of the freedom from dust, the fact that they can operate them day in, day out without a wetting, and because of their simplicity, sturdiness and true running balance.

*Ask for new Bulletin No. 270-M.*

Sullivan Light Water Stoper, "DT-44" with Direct Feed.

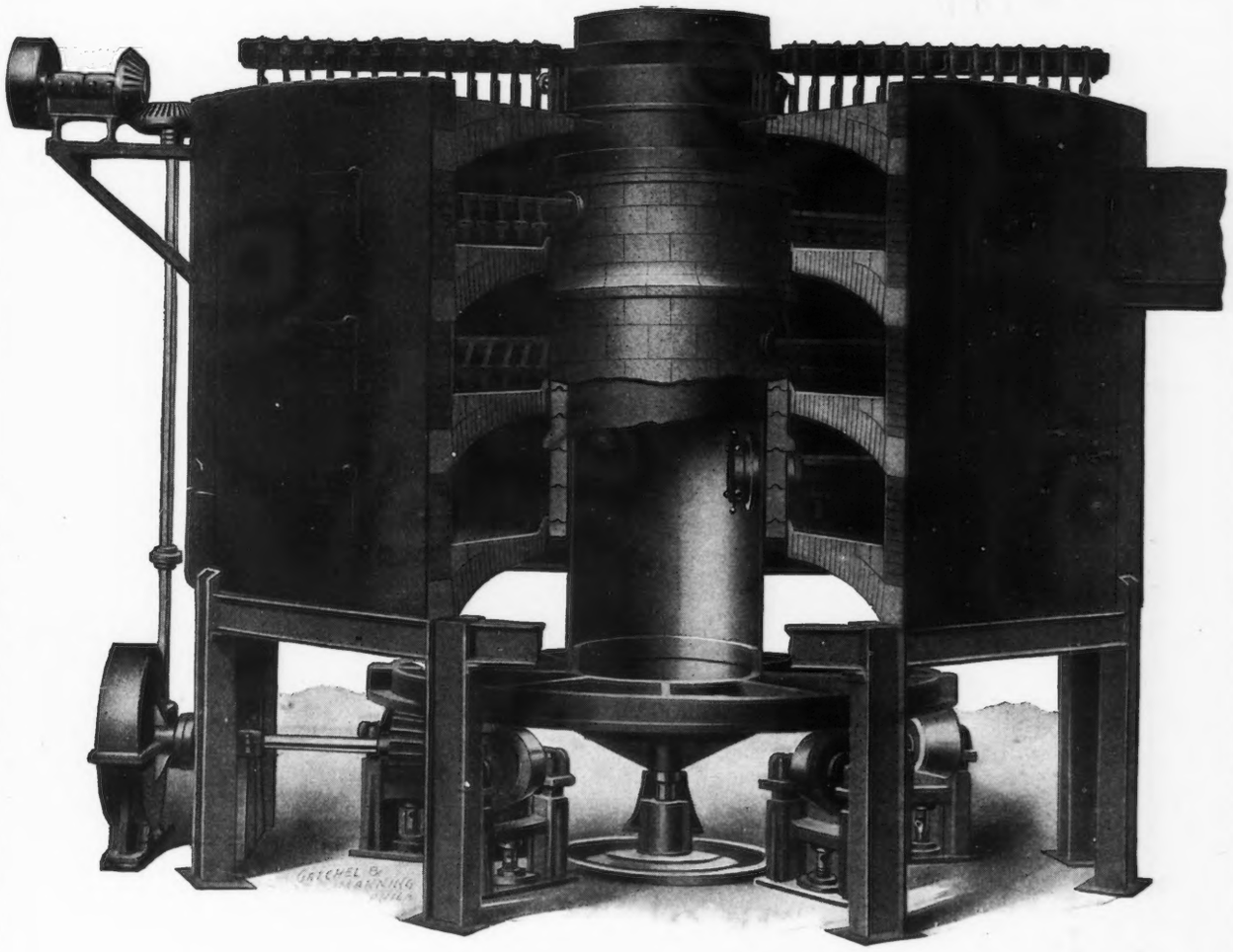
## Sullivan Machinery Company

**126 Michigan Avenue, Chicago**

Boston, Mass. Butte Denver Duluth Juneau London, Eng. Joplin Knoxville Nelson, B. C. New York St. Louis Salt Lake City Paris San Francisco Santiago Spokane Sydney, N. S. W. Pittsburgh Toronto Chile Vancouver, B. C. Turin

# The Wedge Mechanical Furnace

Patented



## Two Desirable Results Obtained

First, Wedge Furnaces are built in different types adapted to different problems; therefore you secure the calcine desired.

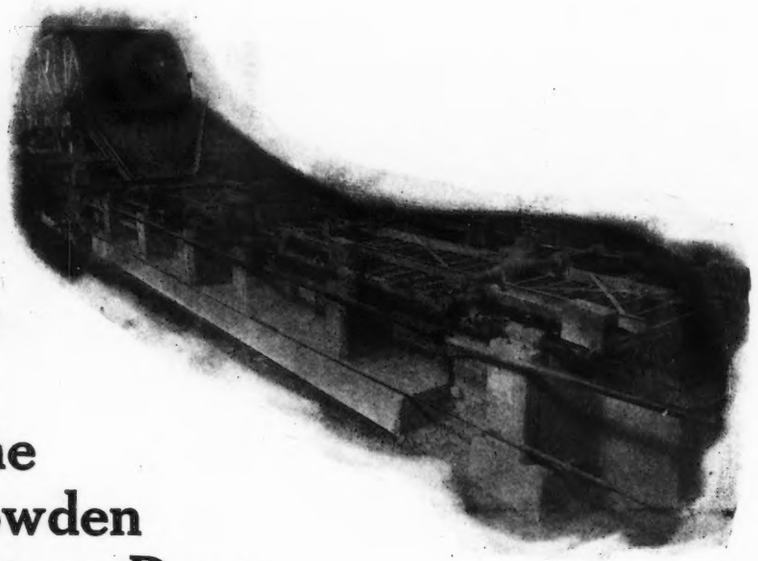
Second, the mechanical construction of the machine insures continuous operation and reduced repair costs.

There are no cast-iron shafts in Wedge Furnaces. The only metal parts exposed to the heat and destructive gases are the arms, rabble blade holders and rabble blades.

Write us stating analysis of ore, concentrates, mixture or material you desire to roast, characteristics and physical condition of same, number of tons to be treated per twenty-four hours, and results desired in the calcine.

## Wedge Mechanical Furnace Company

**Greenwich Point, Philadelphia**



# The Lowden Patent Dryer

The successful drying of flotation concentrates, the sticky colloidal kind that formerly caused so much trouble, is now possible—practically—and efficiently! The whole drying question has been solved by The Lowden Dryer handling any sort of filter cake and reducing the moisture content as low as desired.

There's no reason for shipping water and there's no reason for trying to avoid this difficulty by introducing another— serious dust losses. The Lowden Patent Dryer takes filter cake direct from the drum, moves it along a series of hearth plates, chopped by rabbles, and delivers the dried material directly to the belt conveyor—no clogging or balling—no dust losses, in ideal condition for smelter treatment, and, best of all, without handling while in a condition in which it is difficult to handle.

# Colorado Iron

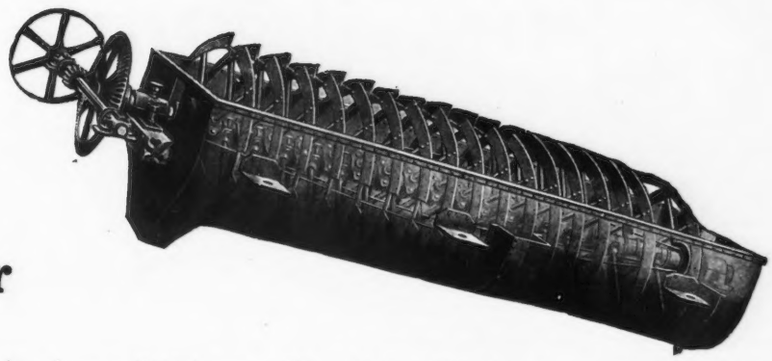
An organization founded over 60 years ago in the heart of our western mining region which has kept in closest touch with every development of milling and smelting practice throughout the world is at your service.

Our large staff of experts in every department, and our long and successful experience under *one management* have given us an established reputation for mill and smelter equipment of the highest efficiency.

We are prepared to design and equip complete plants for ore treatment and take full

## DENVER

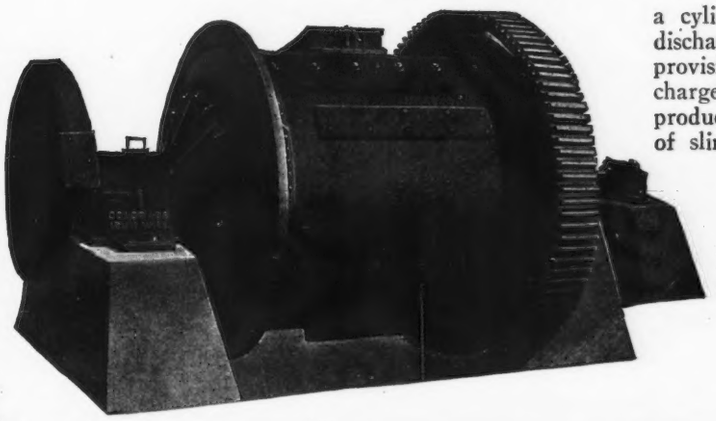
# The Akins Classifier



A clean sand product free from colloidal matter is one of the advantages you secure by the use of Akins Classifier—a clean slime (90 to 95% minus 200 mesh if desired) and the work is accomplished without pulp dilution.

The Akins Classifier is a simple machine without cranks, connecting rods, or other complications—it operates continuously—and effects remarkably close separations—it is ideal in closed circuit with

## The Colorado Ball-Mill



a cylindrical mill with trunnion discharge for fine grinding, and provision for annular grating-discharge whenever a granular sand product is desired with a minimum of slimes.

Colorado Ball Mills have heavy shells—closely fitted head sections—and ample bearings. The trunnions and gear seat turned *after* assembling insure a true running mill. Write for our Bulletin.

# Works Company

charge of erection, you get the results of latest advances in methods and equipment, assembled and housed ready for operation.

We offer the services of the Colorado Iron Works organization freely to help you plan any anticipated milling or smelting operation —and we are equally ready with assistance if you desire a single piece of apparatus; screen, grinding mill or classifier.

We welcome correspondence, it helps us—and will help you.

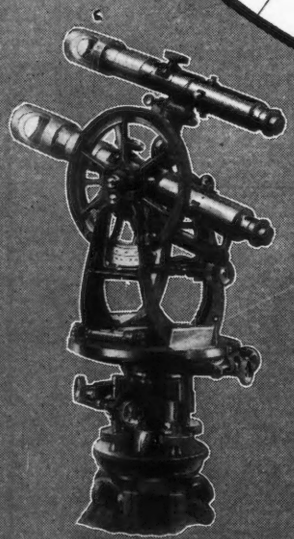
# NEW YORK

# AINSWORTH
## INSTRUMENTS

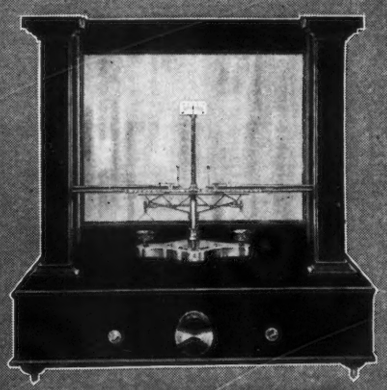
are made in a modern factory, the equipment of which having been largely installed during the past ten years, contains many machines, tools and instruments not to be found in any similar factory.

Expert mechanics, under the direction of men prominent in the American watch making and other precise industries, work along methods that are unequalled for systematic accuracy, and the permanent maintenance of high standards. Hundreds of big industrial and engineering organizations are using Ainsworth Instruments today because "The Precision Factory" has proved the value of its methods in the service given by its products.

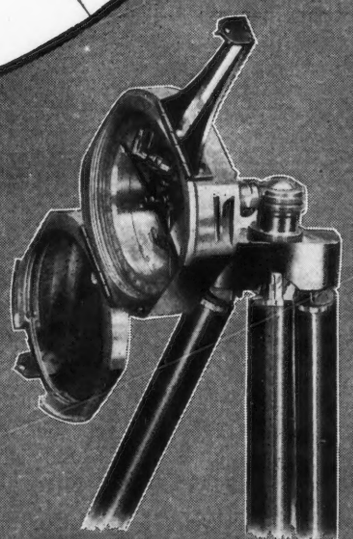
***Send for literature pertaining to the line in which you are interested.***



Type BZ Mining Theodolite with interchangeable auxiliary telescope. Catalog B-8.



Type V Assay Balance. 5-inch beam. Sensitivity 1-500 Mg. Catalog A-8.



Brunton Patent Pocket Transit as used with tripod for reading vertical angles. Bulletin C-8.

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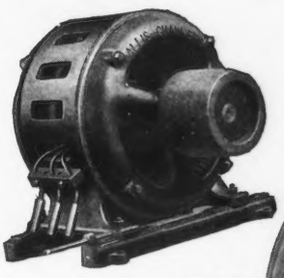
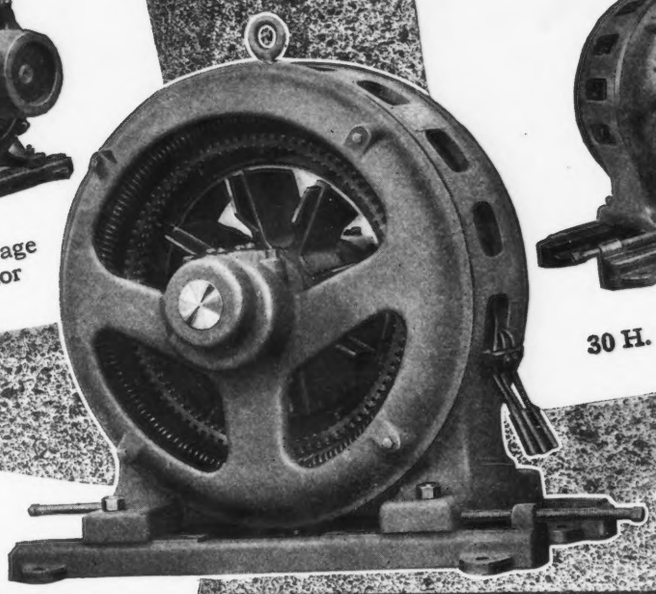
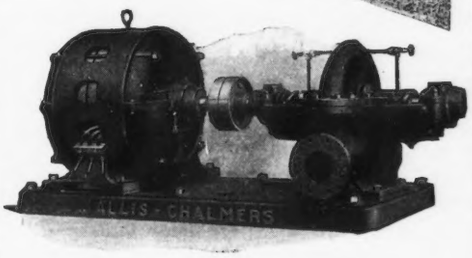


Small Squirrel Cage Induction Motor



30 H. P. Slip Ring Motor

Back Geared Induction Motor —with Gear Case




Motor Driven Centrifugal Pump

# MOTORS

## for Every Industrial Purpose

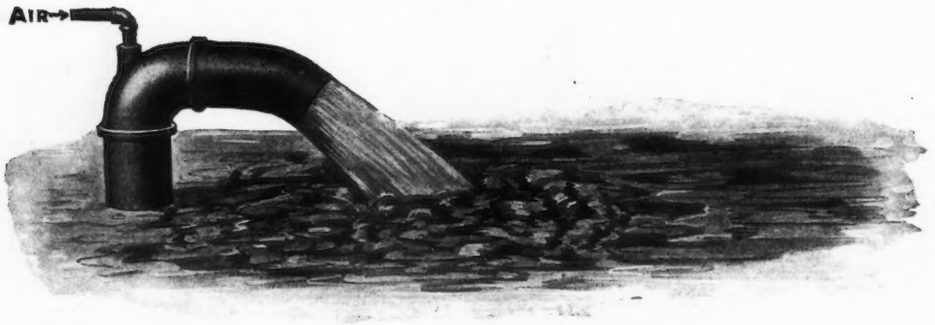
Allis-Chalmers Motors are built in various types designed to meet the characteristics of the driven machines.

Our experience, covering a quarter of a century, in the design, building and commercial application of motors of all kinds is at your service. Our bulletins describe these motors. Any of our sales offices will be pleased to tell you more about them and to assist in the selection of a motor for any particular service.

**District Offices in All Leading Cities**

# ALLIS-CHALMERS

**Milwaukee, Wis., U. S. A.**




# INGERSOLL-RAND
# AIR LIFTS SYSTEMS

**For Pumping Slimes**
**For Handling Tailings**
***And* Transferring Leaching Solutions**

The Air Lift has every advantage over other methods of handling corrosive liquids and gritty mixtures. It is economical of power, inexpensive in attendance cost, capable of continuous operation and in a class by itself as regards the maintenance item.

With the Air Lift there is nothing in contact with the fluid pumped by compressed air and simple piping—no impellers or pump parts to need constant replacement with attendant material, time and labor expense. The only moving mechanism is an air compressor located wherever convenient and operating under conditions favorable to a long life of unimpaired efficiency.

## *Here is the experience of two users:—*

One of the largest mining companies in the Southwest has been handling tailings with centrifugal pumps—which were of necessity renewed about every four days at enormous expense.

The installation of an Air Lift demonstrated that tailings can be handled with no more wear and tear or attendance than is the case with the most reliable machinery in the power house.

Based on these test results, a complete Air Lift Pumping Plant is now being installed, which will entirely replace the sand pumps.

At the plant of a large copper company the leaching system called for the carrying of sulphuric acid solutions to successive concrete tanks.

The Air Lift was installed as a means of handling the corrosive solution without continual interruption of the system for pump repairs. The result is highly satisfactory and the relative cost remarkably low. The piping equipment is lead lined, and as there is no movement of parts, is proving long lived even under unusually severe conditions.

**The experience of the Company's staff of Air Lift Engineers is at the disposal of those interested.**

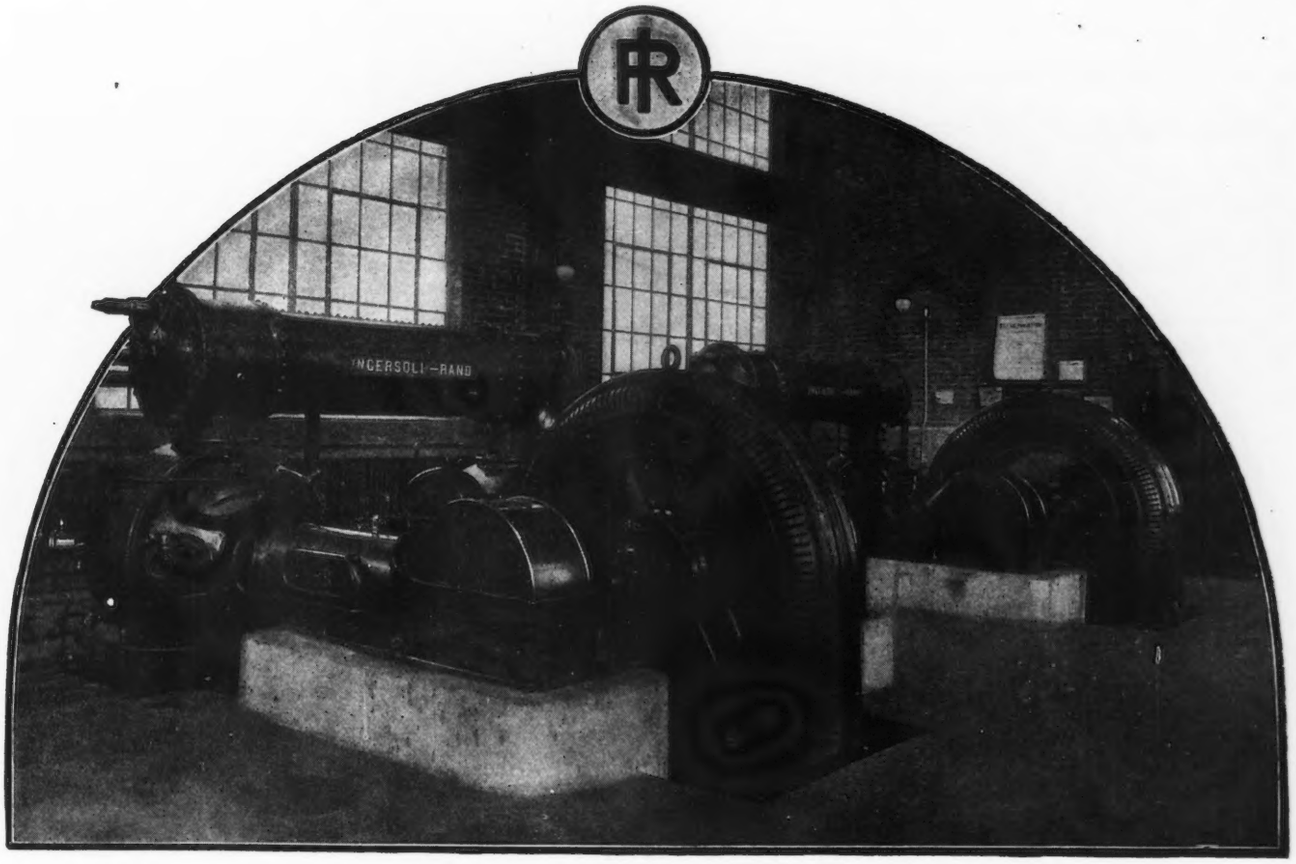
***Write Us for Further Details***

# INGERSOLL-RAND COMPANY

**11 Broadway, New York** **165 Q. Victoria St., London**

***Offices the World Over***

144-M




# Ingersoll-Rand Air Service

## For the Mine

When you men install an air plant you count on making a permanent investment; you buy high efficiency and mechanical superiority on the basis that in the long run you will save money.

The Ingersoll-Rand Company builds only machines of the high grade you insist on having.

Class "PRE" electrically driven units, such as are installed in the shops above, will maintain reliable air service with less horsepower input per cu. ft. than is otherwise obtainable. A strong statement but one that is substantiated by the experience of hundreds of users.

I-R Compressors are built in all sizes, types and capacities.

*Ask for the Bulletins.*

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Type XB—Belted
176-3508 cu.ft.

No. 3033
Type XPV—Steam
608-4219 cu.ft.

No. 3126
Class PRE—Electric
1000-7500 cu.ft.

No. 3219
Class ORC—Corliss
1200-8000 cu.ft.

365-C

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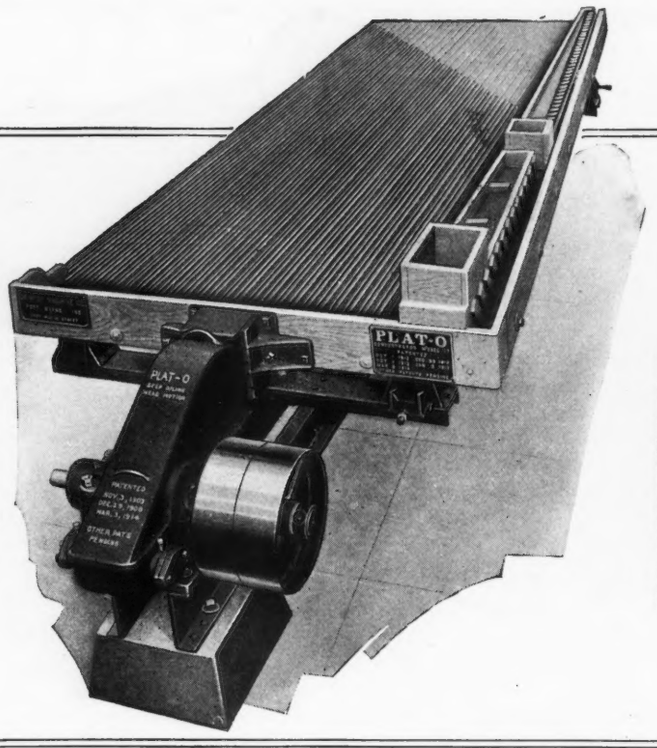
DOMESTIC OFFICES

BUTTE, JUNEAU, DULUTH, DENVER, BOSTON, EL PASO, SEATTLE, ST. LOUIS, CHICAGO, NEW YORK, KNOXVILLE, SCRANTON, HOUGHTON, CLEVELAND, PITTSBURGH, BIRMINGHAM, LOS ANGELES, DETROIT, NEW ORLEANS, PHILADELPHIA, SAN FRANCISCO, SALT LAKE CITY, JOPLIN

FOREIGN OFFICES

LONDON, PARIS, MADRID, MILAN, RIO DE JANEIRO, MONTREAL, MEXICO CITY, MELBOURNE, KALGOORLIE, JOHANNESBURG, SANTIAGO, CHILE, LIMA, PERU, KOBE, JAPAN, MANILA, TOKIO, HONOLULU, HAVANA, BUENOS AIRES, ANTOFAGASTA, LA PAZ, BOLIVIA, VANCOUVER, B. C.

APPLY TO NEAREST OFFICE




**Some Users**

Arizona Copper Co., Ltd.
New Cornelia Copper Co.
Old Dominion Co.
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# The "PLATEAU," the Wide Riffles, the Mechanical Perfection

Of PLAT-O Concentrating tables, combine to give action with a speed and a thoroughness never before equaled in table concentration. The wide riffles advance the sands quickly by DISPLACEMENT. The short up-hill travel to the "plateau" gives a final close separation. The narrow 3/8 in.-deep channels hold the mineral. The concentrate is clean; middlings, notable by their absence.

In short, Plat-O Concentrating Tables give *action* that spells the last word in Capacity, Recovery, Easy and Low Cost Operation.

***Write for the new illustrated bulletin.***

## DEISTER MACHINE COMPANY

**East Wayne St., Ft. Wayne, Ind.**

# PLAT-O

ANOTHER thing, it seems so ridiculously obvious that a shoveler can do better work with a shovel that suits him that shortly there won't be anybody neglecting this feature.

Also that a light, well-balanced shovel, but also tough, cannot be made of ordinary materials. A blade that has to be made heavy to make any kind of respectable showing as to wear sacrifices the demand for lightness.

If ordinary materials are made light, in order to attain that desired factor, then strength and wearing ability of the blade needs be lost.

There cannot be any compromise.

Evidently, and evidently without question, the only materials that can be used for shovels and fill all the requirements are Heat Treated, Chrome Nickel, Steel Blades and XX Second Growth Northern White Ash Handles.

Think of what such shovels will do?

Increase the daily output per man from 8.5

tons per day to 22.9 tons per day and decrease the shovel bill per ton by 20%.

Red Edge Shovels are doing it.

We are glad we do not have to offer these figures as our own. They might not be believed. They are figures for a year from a source that cannot be disputed, and we know of a lot of places where similar results are being obtained.

From now on the use of or refusal of such opportunities is going to determine who makes money and stays in business and who doesn't.

It is so ridiculously easy to get Red Edge Shovels there isn't any excuse for not having them.

A large majority of the successful Operators have adopted them as Standard.

Don't let any shovel orders or requisitions go out not specified as RED EDGE.

THE WYOMING SHOVEL WORKS

WYOMING, PENNA., U. S. A.

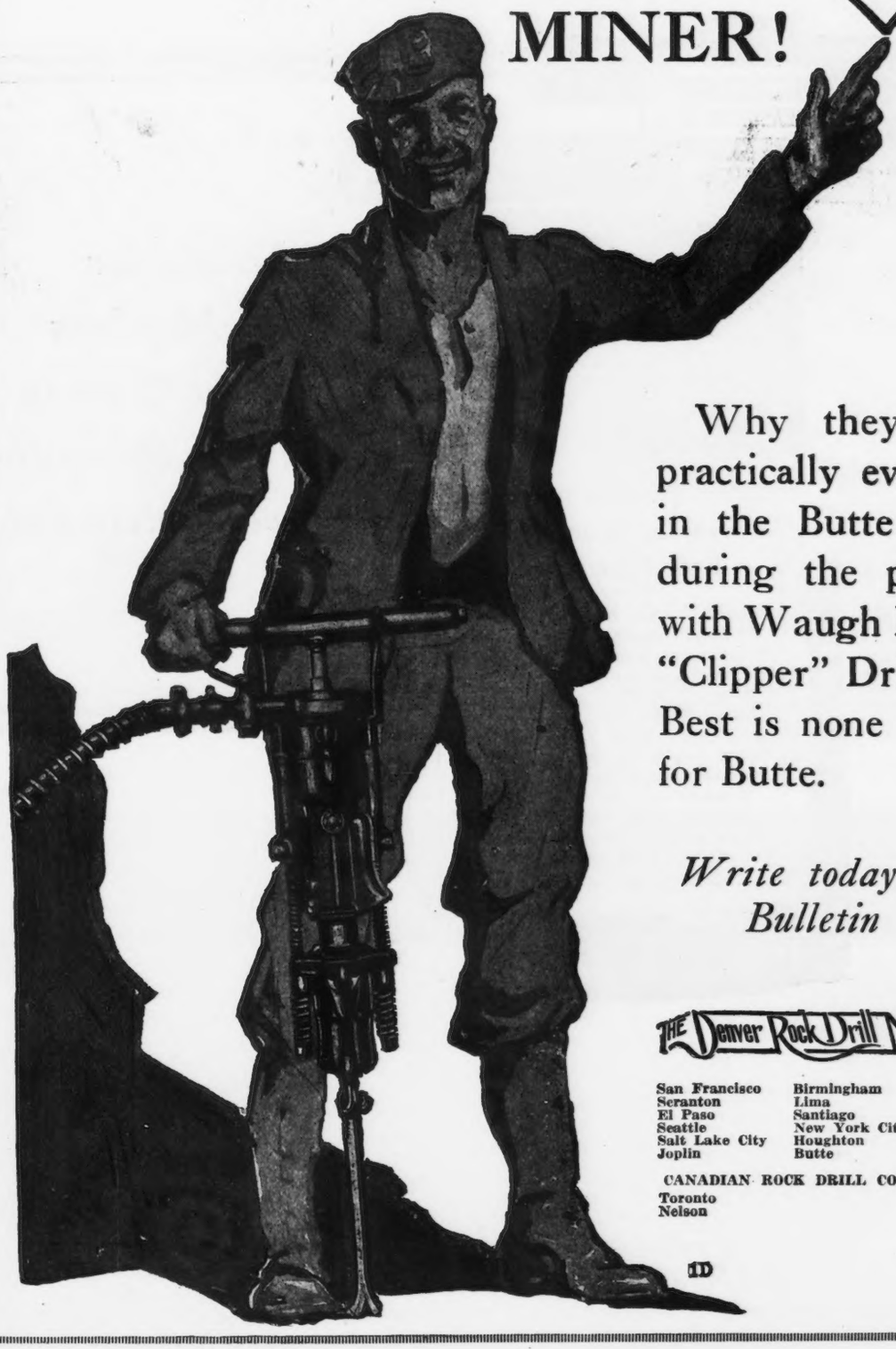
WYOMING
RED EDGE
SHOVELS

# ASK ANY MONTANA MINER!

The Best Rock Drills Bear This Mark

ROCK WAUGH DRILLS

Look For It!



Why they've sunk practically every shaft in the Butte District during the past year with Waugh Model 55 "Clipper" Drills—The Best is none too good for Butte.

*Write today for our Bulletin C-5.*

THE Denver Rock Drill Manufacturing Co.

| | | |
|---|---|---|
| San Francisco | Birmingham | Los Angeles |
| Scranton | Lima | Wallace |
| El Paso | Santiago | Mexico |
| Seattle | New York City | Melbourne |
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CANADIAN ROCK DRILL CO., LTD., Sole Agents

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| Toronto | Cobalt |
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1D

E-73

THE FIRST CAST IRON PIPE EVER MADE IN THE WORLD'S HISTORY IS STILL IN SERVICE
SERVICE
CAST IRON PIPE
MEASURED BY
CAST IRON PIPE
CENTURIES
MORE THAN 250 YEARS OLD

Fountains in the Park at Versailles, France

***Versailles Fountains Tested for Peace Fete***

VERSAILLES, May 22 (By The Associated Press). — The great fountains at Versailles were turned on this morning for a test preliminary to the grand display planned for the day the peace treaty is signed. They functioned perfectly, despite the fact they had not been used since the war began.

Members of the German peace delegation were interested spectators, the display being visible from the windows of their hotels.

***No wonder "the Members of the German Peace Delegation were Interested."***

WHEN one reflects that the pipe which enabled "Les Grandes Eaux" in the Park at Versailles to function properly—in spite of the fact that that cast iron pipe was installed prior to the opening of the park, back in 1685—234 years ago—it is no wonder "the German Peace Delegation were interested."

Pipe which gives faithful service for nearly two and a half Centuries should interest everybody.

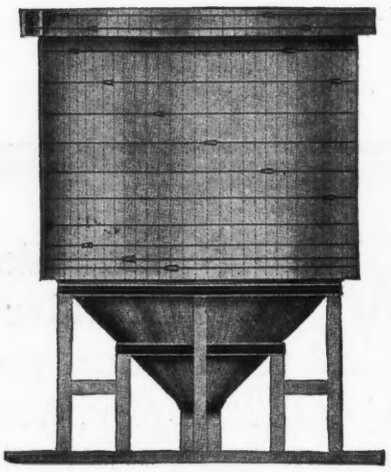
CAST IRON PIPE PUBLICITY BUREAU

1 Broadway New York

# Reduce Your Tank Costs

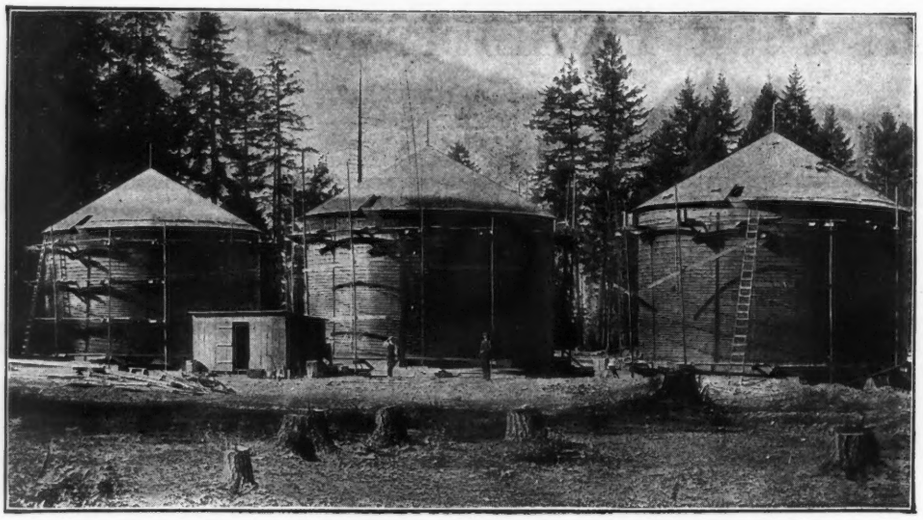
As you know certain acids and mining chemicals will soon soften and destroy certain kinds of tank woods quicker than others. Douglas Fir and California Red wood have proven the most substantial and the most durable. When should you use fir and when redwood? This is an important question in reducing your tank costs.

We make tanks from both these woods, fitting each for specific purposes—oils, water, acids, etc. We furnish all shapes, round, rectangular, semi-circular, open and closed tops, and conical bottoms. We carry in stock tanks from 500 to 10,000 gallons capacity which can be shipped immediately by water or rail. Other sizes made on specifications.



**Settling or Agitating Tank. Made in all sizes.**

Write us and we will be glad to give you our experience and suggestions regarding the kind of wood best suited to your purpose. No obligations. Also ask for our specifications and prices.



**These huge "National" tanks were erected at Camp Lewis, American Lake, Washington, as storage tanks for the water system. Each tank has a capacity of 200,000 gallons.**

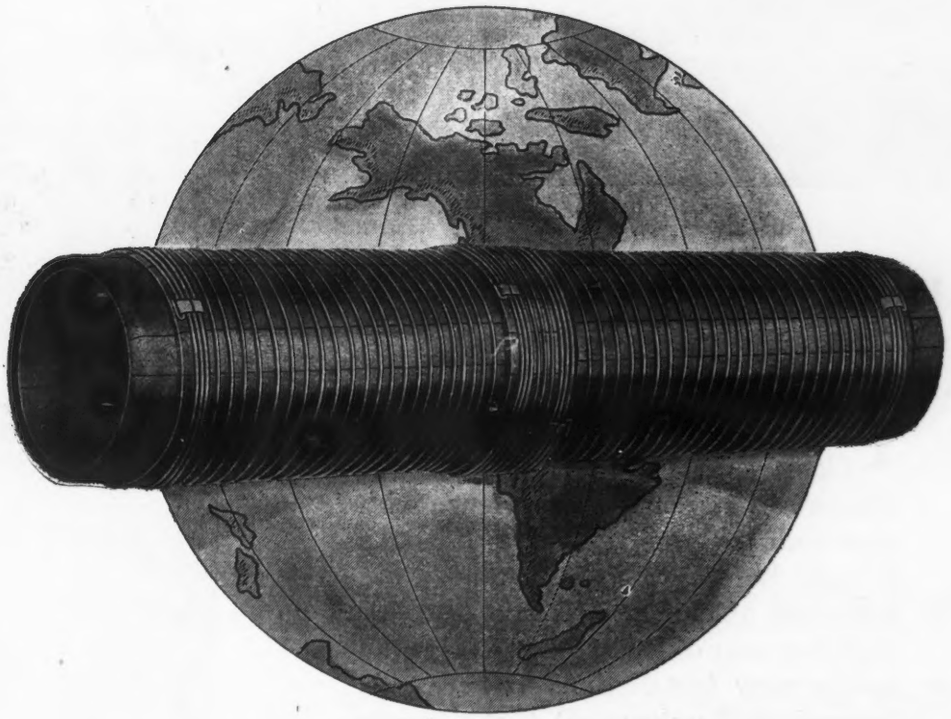
***We manufacture complete Cyanide plants either standard or on special specifications.***

## NATIONAL TANK & PIPE CO.

**PORTLAND 275 OAK ST. OREGON**

# Two-Thirds of the way around the World—

from France in the West



to the Indies in the East

# REMCO

## PIPE AND TANKS

—are used—because of marked superiority of manufacture and highest quality of material, resulting in highest efficiency in use.

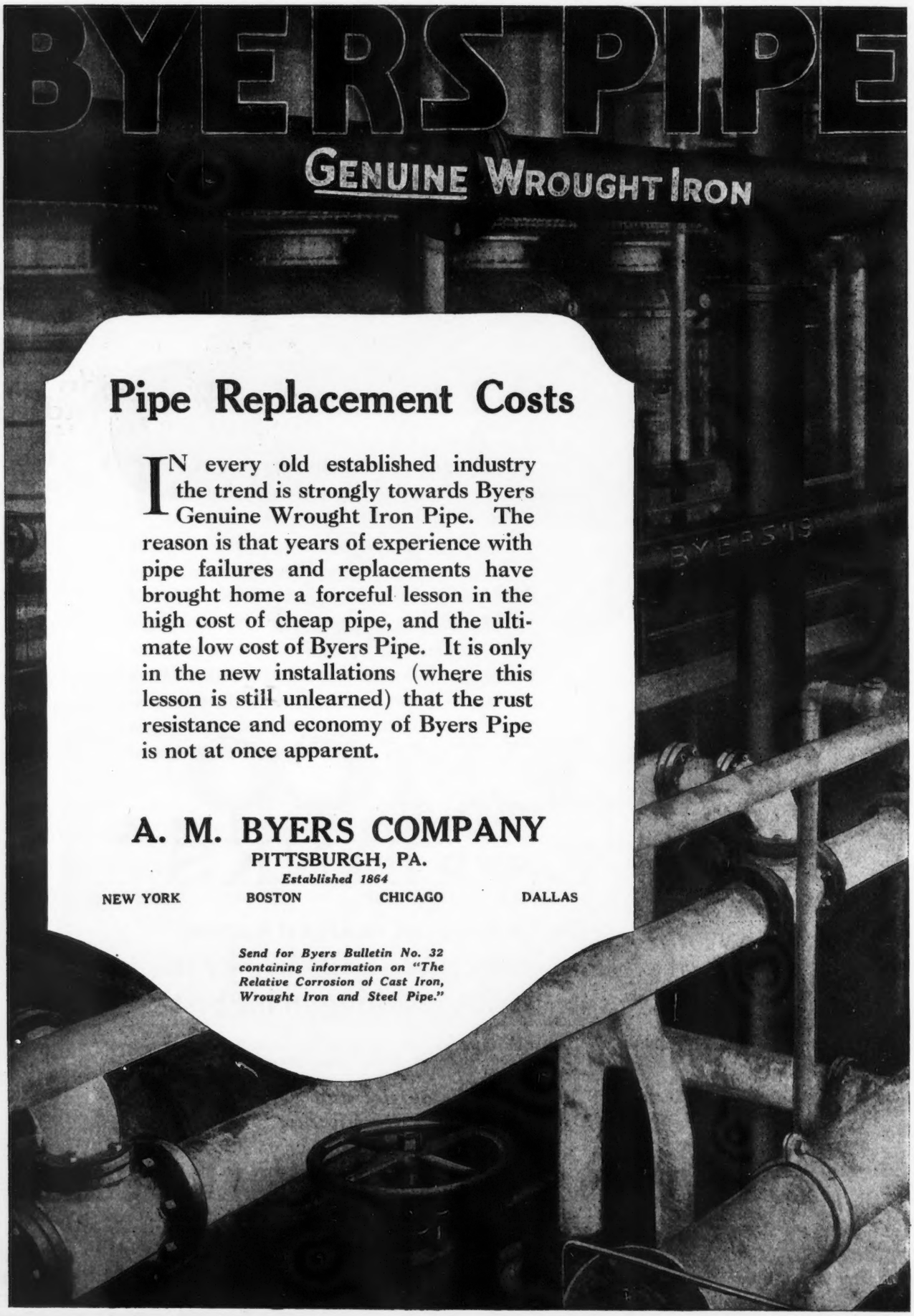
***Write for Catalogue and Quotations on YOUR Requirements.***

## REDWOOD MANUFACTURERS CO.

**1660 Hobart Building, San Francisco**

**"REDWOOD for Durability"**

**"REMCO for Mechanical Perfection"**

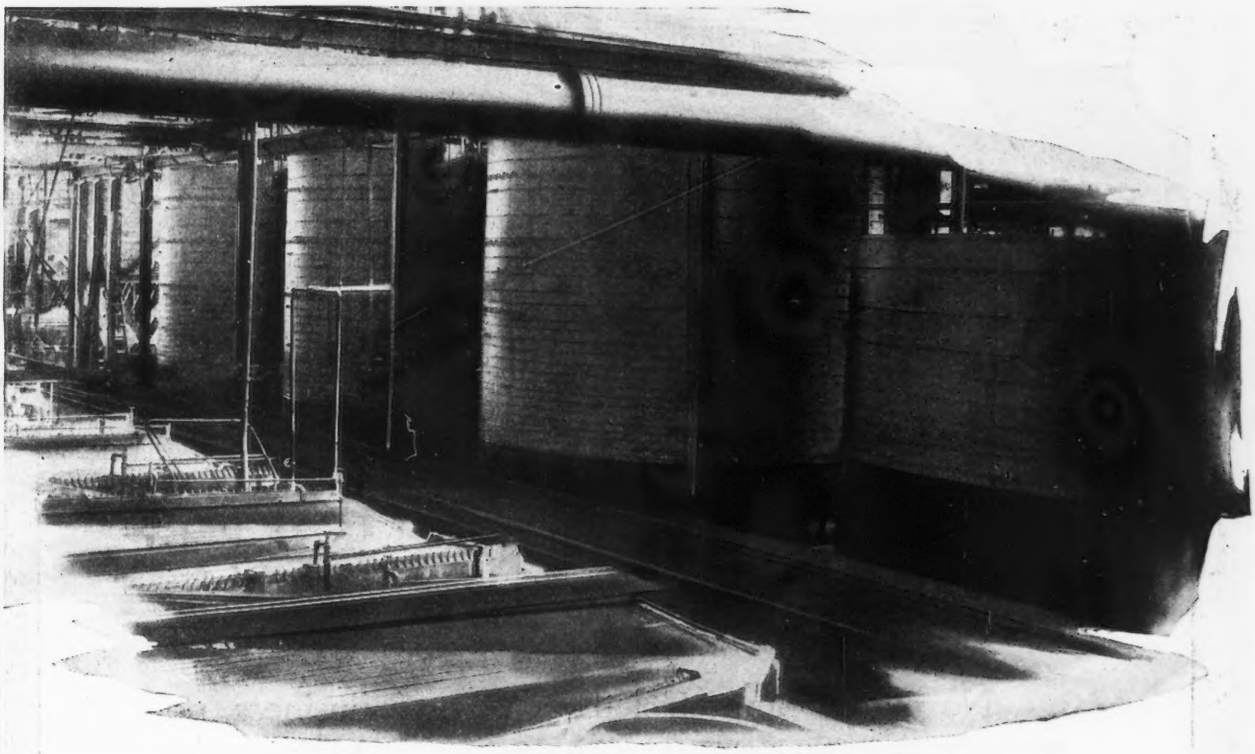



## Pipe Replacement Costs

IN every old established industry the trend is strongly towards Byers Genuine Wrought Iron Pipe. The reason is that years of experience with pipe failures and replacements have brought home a forceful lesson in the high cost of cheap pipe, and the ultimate low cost of Byers Pipe. It is only in the new installations (where this lesson is still unlearned) that the rust resistance and economy of Byers Pipe is not at once apparent.

**A. M. BYERS COMPANY**
PITTSBURGH, PA.
*Established 1864*
NEW YORK BOSTON CHICAGO DALLAS

*Send for Byers Bulletin No. 32 containing information on "The Relative Corrosion of Cast Iron, Wrought Iron and Steel Pipe."*



*One of our mill installations at Calumet and Hecla*

# Consider Tank Efficiency

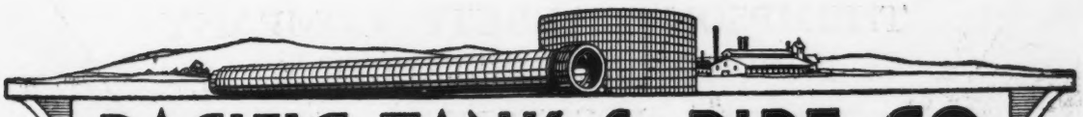
—it's a part of your plant economy—just as much as any other necessity of milling or metallurgical equipment—therefore consider the efficiency, costs and adaptability to your process.

Pacific Redwood Tanks and Pipe are constructed on correct engineering principles. It makes no difference whether it be in Alaska, or Mexico or in Africa or China. Pacific Products have proved their efficiency under all climatic conditions.

The service they have given mining engineers during the past thirty years has made them the standards for wooden tanks and pipe.

***Let us help you—write or wire us today.***

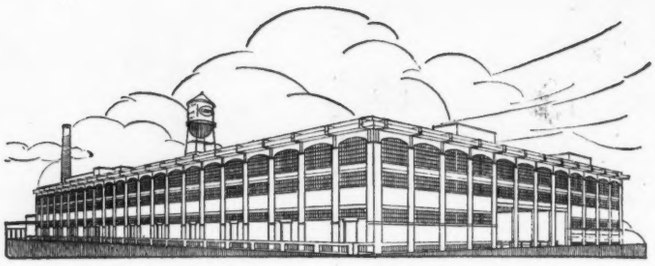
**Solution Tanks**
**Leaching Tanks**
**Parral Agitation Tanks**
**Flotation Cells**
**Precipitation Boxes**
**Pachuca Tanks**
**Oil Tanks**
**Wood Stave Pipe**
**Acid Tanks**



## PACIFIC TANK & PIPE CO.

**THE STANDARD SINCE 88**

304 Market Street, San Francisco. 310 Munsey Bldg., Washington, D. C. 6080 Metropolitan Bldg., New York. 903 Trust and Savings Bank Bldg., Los Angeles. 420 Liberty Bldg., Philadelphia. 323 Newhouse Bldg., Salt Lake City, Utah.



AMERICAN CAN CO., FACTORY, MAYWOOD, ILL.

# INVESTIGATE BEFORE YOU INVEST

**No matter how efficient in its own business, no organization can dispense with competent advice on its plant extensions, anymore than a lawyer can dispense with a doctor when he is sick or a doctor dispense with a lawyer when he sues a client for his bill.**

**And pursuing the simile further, merely hiring any organization of engineers or contractors that makes plausible claims, without scrutinizing its credentials of ability, is as dangerous as hiring a lawyer or a doctor without regard to his record.**

**The Thompson-Starrett Company is not only competent to undertake your plant extensions, but its advice is constantly solicited and followed in the investigative stages of construction problems, by organizations which want specialized advice before they commit themselves to a contract.**

*Our Advice is as Good as Our Service*

**THOMPSON-STARRETT COMPANY**
**INDUSTRIAL CONSTRUCTION**
**NEW YORK**
**CHICAGO** **PITTSBURGH**

TRADE MARK
PABCO PRODUCTS

PABCO 10 and 20 Year GUARANTEED ROOFS
ROOFINGS
BUILDING PAPERS
WALL-BOARD
INDUSTRIAL PAINTS

BOX-BOARD
PAPER-BOXES
FIBRE CONTAINERS

# There is a PABCO PAINT to meet your need

Whatever the surface to be protected—exterior or interior—wood, iron or cement, you'll find a PABCO Paint **for that specific purpose.**
Mines, Mills, Smelters and Industrial Plants have long recognized the **extra value** in the protection afforded by a right selection from the well known line of PABCO Industrial Paints.

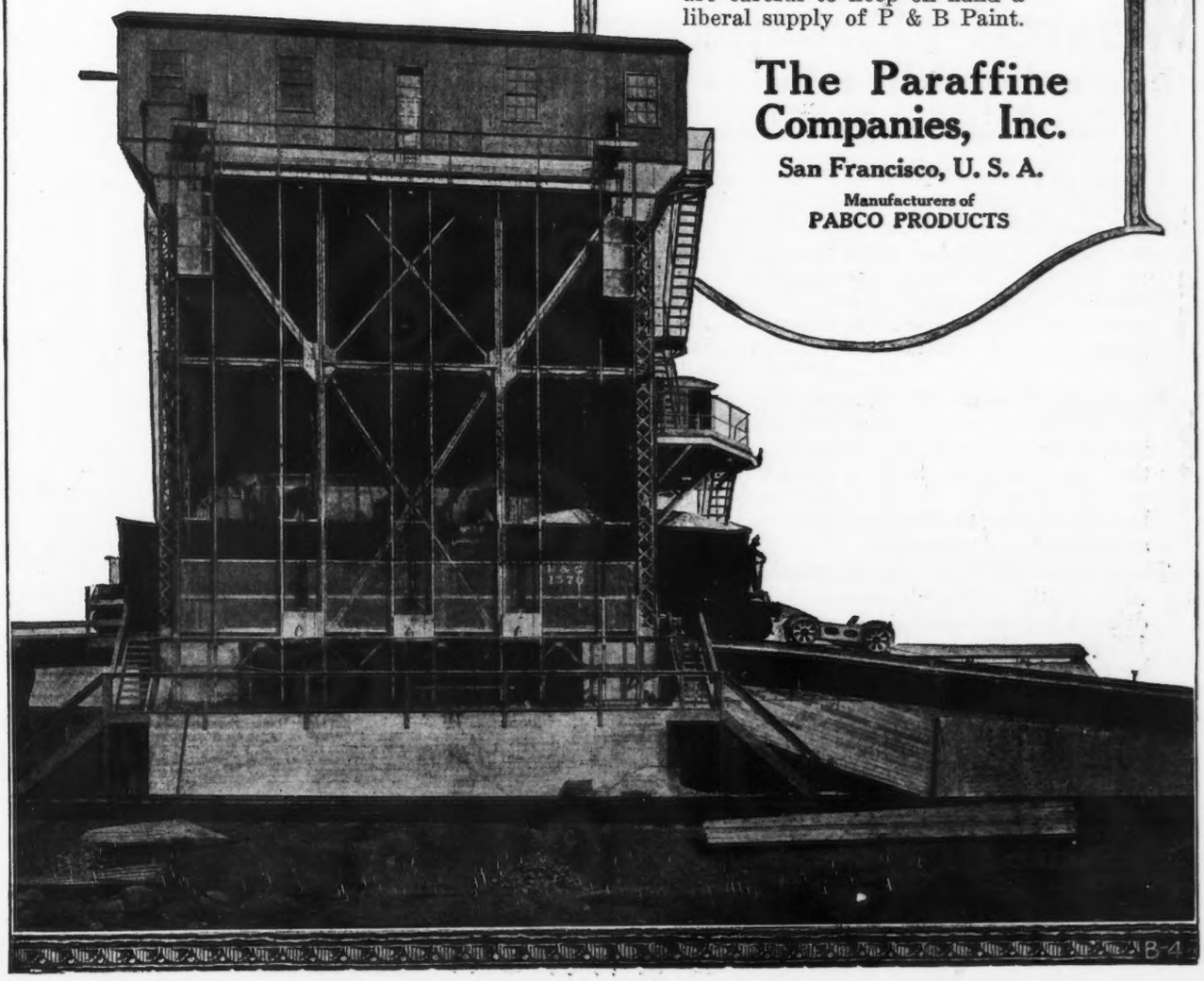
**Our Famous P & B Paints**

are known throughout the mining field as unequalled for resisting acid and alkaline action, corrosion and heat. Most mines are careful to keep on hand a liberal supply of P & B Paint.

## The Paraffine Companies, Inc.

**San Francisco, U. S. A.**

Manufacturers of
PABCO PRODUCTS



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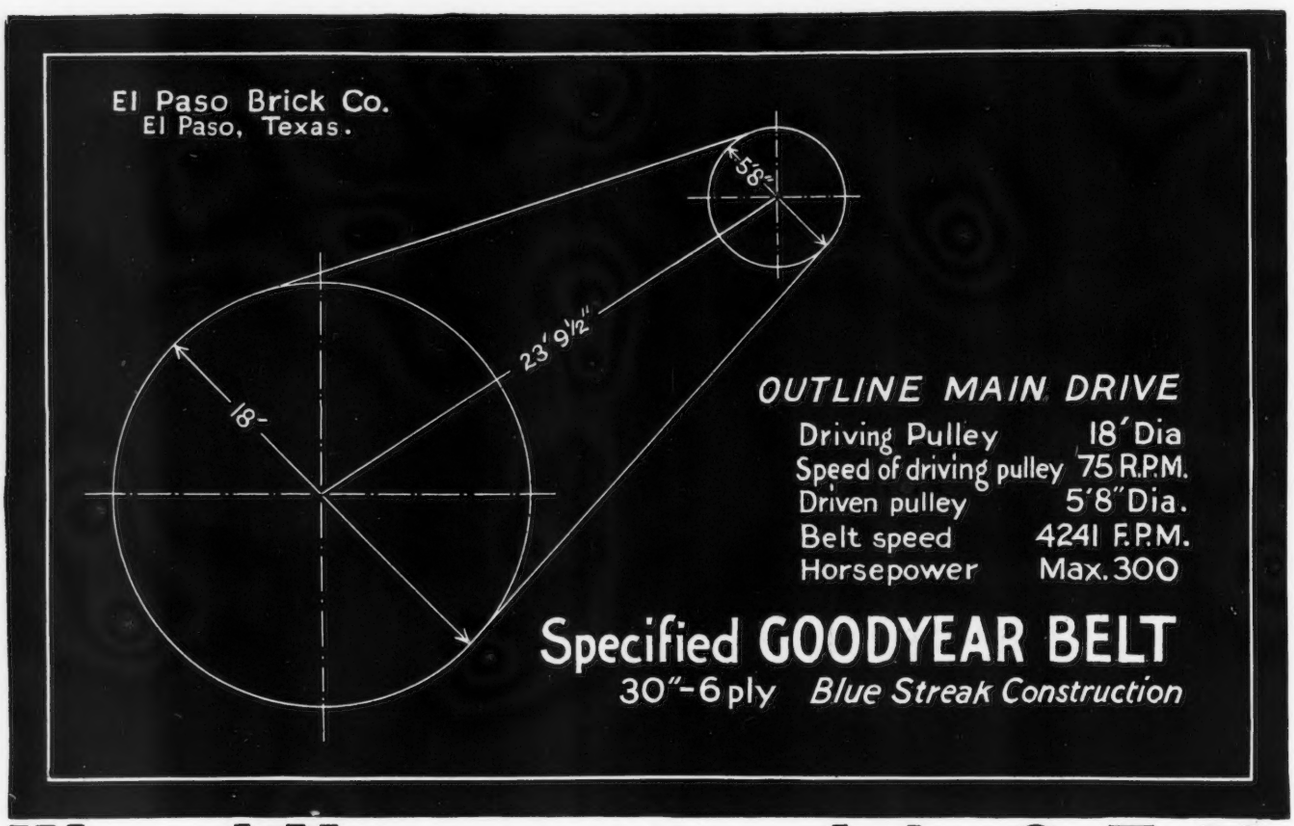



# Wasted Horsepower—and the G. T. M.

***It was a spendthrift of power*** and a trouble-maker of the first class, that main-drive in the El Paso Brick Company's plant. Some years ago it was all right, but as the company grew it got worse and worse. Every kind and many grades of belt were tried on it. They slipped and jumped and stretched. They wasted horsepower-hours by the hundred. Most of them lasted only four or six months. The most expensive ran their unreliable way for about a year. They made that main-drive one of the most costly things in the plant. Finally the manager, Mr. Rodgers, asked a G. T. M.—Goodyear Technical Man—to call.

***The G. T. M.—our Mr. Watson—was told by*** Mr. Rodgers that it was planned to try out an 18-inch 8-ply Goodyear Belt of Blue Streak construction, but that it would be a good thing to look over the drive first. The G. T. M. thought it would be a good thing to *study* the drive—so they went and looked and measured.

***There was 300 horsepower coming off*** a fly wheel with a 40-inch face and intended for delivery to a shaft-pulley *with an 18-inch face.* But 105 of the 300 were being wasted by slippage, because that line-shaft pulley-face hadn't grown with the plant.

***The G. T. M. recommended to Mr. Rodgers*** that he put on a line-shaft pulley with a face to take a 30-inch belt, specified a 30-inch 6-ply Blue Streak, stated his reasons, and was told to go ahead. He did. The belt and the new pulley were installed in April, 1918, and that main-drive has been a joy ever since.

***From the first more than 100 of the 105 horsepower*** formerly wasted has been saved. The belt runs with perfect smoothness and evenness. And it costs much less than those that used to slip, stretch and break under overload, and waste a thousand horsepower-hours in an ordinary working day. And in Mr. Rodgers' judgment the Goodyear Belt is good for several more years.

***There are many main-drives for which*** a G. T. M. can do similar things—main-drives still belted according to precedent instead of in accordance with the real conditions. Not all of them have outgrown pulley-faces, but many have; and scores of others are using belts of the wrong construction, others have belts made of materials that require such extraordinary tightening that they are hard on bearings, cause shafting to weave, and waste power and time in many other ways.

***Ask a G. T. M. to look over your main-drive.*** He will call when next he is in your vicinity. He may find it all right—and if it is, he will tell you so. If it isn't, and he recommends certain changes, you are in no way obligated to carry them out unless his reasons convince you.

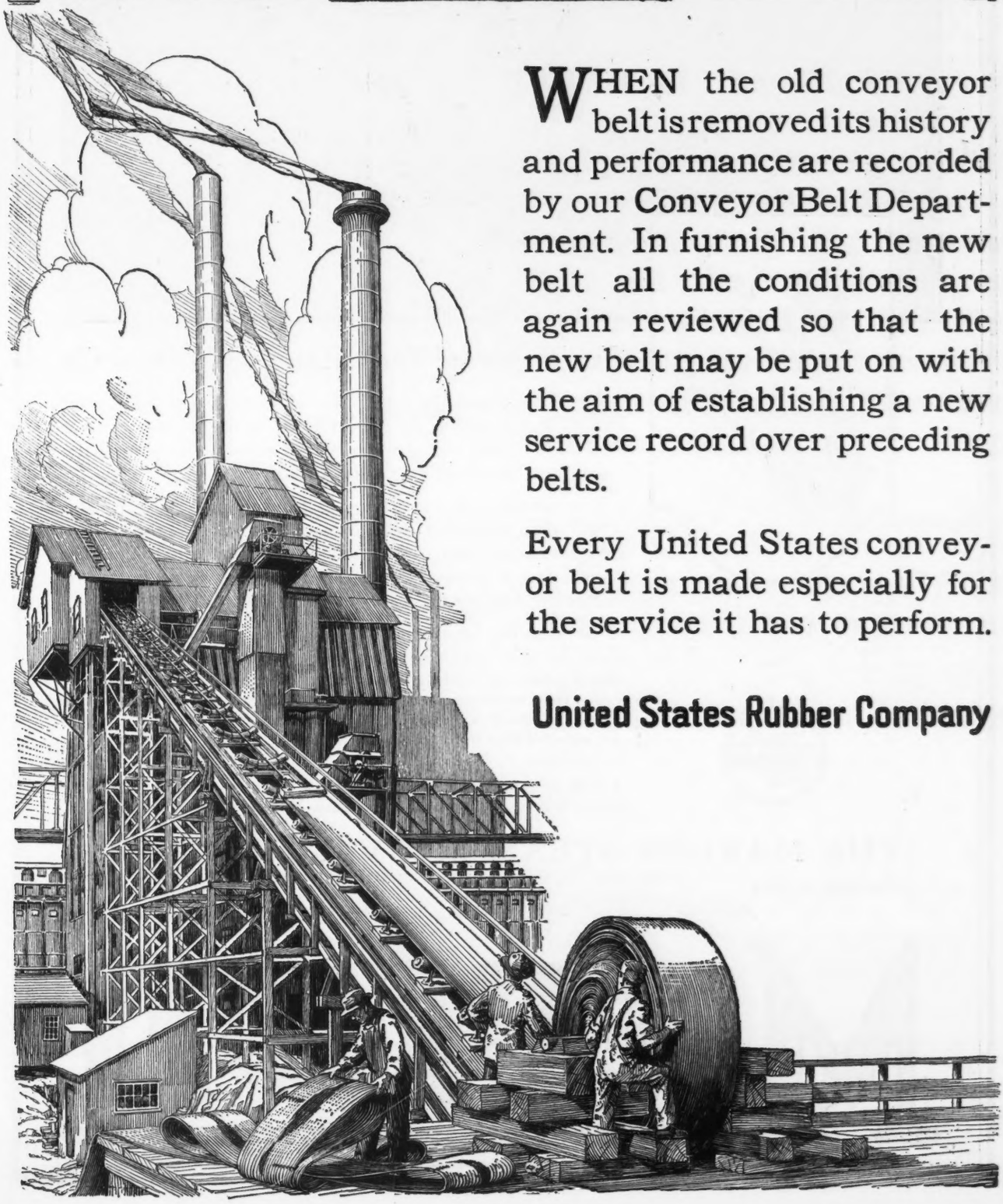
BELTING · PACKING · HOSE · VALVES

GOODYEAR

AKRON

US
UNITED STATES RUBBER COMPANY AND ASSOCIATED COMPANIES
RUBBER SYSTEM

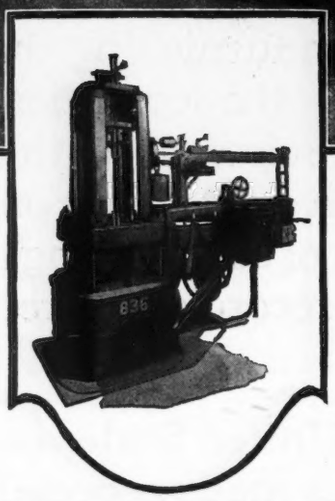
# Conveyor Belts



WHEN the old conveyor belt is removed its history and performance are recorded by our Conveyor Belt Department. In furnishing the new belt all the conditions are again reviewed so that the new belt may be put on with the aim of establishing a new service record over preceding belts.

Every United States conveyor belt is made especially for the service it has to perform.

**United States Rubber Company**




*Testing machine in physical laboratory at the "Marion" plant to determine the strength of various individual parts of "Marion"-built equipment. We have several such machines and keep them busy!*

## Ten Thousand Tons a Day—2 Years to Go

**This Model 300 "Marion" Shovel, owned at its Hull Rust Pit, Hibbing, Minn., by the Oliver Iron Mining Co. of Duluth, is biting straight into a cut of ore—digging at the rate of ten thousand tons a day or better.**

**Car shortage has prevented it from working steadily, but it has maintained the average and will work full time whenever there are cars to be loaded. It is estimated that the shovel has a two-years' job ahead of it (three million tons) before the loading track will need moving.**

**Besides the economies offered through its big yardage, this "Marion" saves in other ways. Loading track is 35 feet above grade—ore cars can be moved more cheaply and in longer trains than when tracks have to be run into pit. The shovel takes an exceptionally wide cut—120 feet in this case. Track-laying costs are reduced to a minimum—the "Marion" takes a greater tonnage as it goes.**

**You will find "Marion" equipment on most of the important metal mining operations. We shall be glad to send particulars.**

## THE MARION STEAM SHOVEL COMPANY

*Established 1884* Marion, Ohio

CHICAGO NEW YORK SAN FRANCISCO

# Marion

AETNA DYNAMITE—of a particular grade that will suit your individual requirements—should be the first point to turn to on your dial of blasting problems, because it is so made as to represent, figuratively, when properly loaded, the right "tumbler" in your locked-up strata. And, Aetna Dynamites differ essentially from most brands in that they produce less fumes.

Turning to "Lion" Electric Blasting Caps, they contain a Fulminate of Mercury charge, which makes them the most dependable and efficient detonator known. We direct your attention to the .30-calibre diameter of "Lion" Electric Blasting Caps. The advantage of this diameter shell is that it gives the maximum concentration of charge, which is of vital importance. If a smaller diameter shell is used the same sized charge would be proportionately longer, and instead of a powerful blow being delivered upon a small area—such as our .30-calibre shell gives—there would be a diminished one over an extended area, with the possibility of imperfect detonation.

Then turning to Proper Loading, we find a point that is often out of true in general practice. We will mention here only one instance We have known of blasters who have put an Electric Blasting Cap with a four-foot lead in a hole twenty feet deep and then attached light connecting wire to it because it is cheaper than the longer wires of a twenty-foot electric blasting cap which are made to withstand a greater pressure. No matter how carefully a joint is made, there is more resistance to the firing current in a joint than there is in solid wire. This idea—and we have seen it used many times—is a mighty expensive attempt at economy. Proper loading, from the first stick of dynamite to the top of the tamping, and the making of proper connections, is all important.

Finishing up the combination with a "Lion" Blasting Machine, we have in it a powerful dynamo, simply constructed, yet in such a way, and of such materials, that it withstands hard usage and comes as near taking care of itself as any machine can.

## AETNA EXPLOSIVES COMPANY, INC.

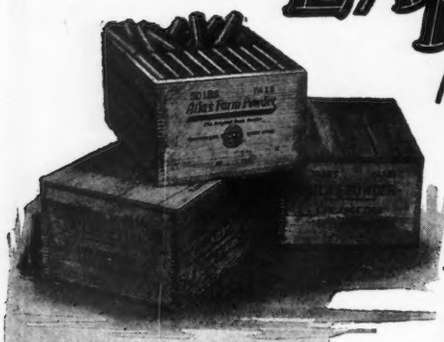
### New York City

BRANCH OFFICES:

Birmingham, Ala.
Buffalo, N. Y.
Chicago, Ill.
Denver, Colo.
Duluth, Minn.
Joplin, Mo.
Louisville, Ky.
New Orleans, La.
Norristown, Pa.
Pittsburgh, Pa.
Pottsville, Pa.
Roanoke, Va.
St. Louis, Mo.
Wilkes-Barre, Pa.

# Explosives

## for every blasting requirement



*for*

Road Building
Excavating
Ore Mining
Coal Mining
Quarrying
Demolition
Agriculture

*More than 100 Different Kinds*

Dynamite
Permissible Explosives
Gelatin Dynamite
Blasting Gelatin
Extra Dynamite
Oil Well Explosive
Quarry Powder
Farm Powder
Low Powders
Blasting Powders
Sporting Powders
Blasting Supplies

Atlas Explosives are manufactured with specific characteristics for different classes of work. The various Atlas brands differ in strength, quickness, sensitiveness, resistance to cold, fumes evolved on detonation and resistance to water, according to the requirements of the work for which the explosive is to be used. The qualities most needed in one class of work may be worthless or actually derogatory in another.

To insure Atlas users getting the best results with the greatest economy of time, labor and money, we maintain the Atlas Service Division. Here is a corps of experts who are thoroughly conversant with the exact properties of every explosive and the most efficient methods of using them.

When you are in doubt on any question pertaining to explosives write and explain your troubles to our Service Division. They will give you the correct solution to your problem and, if necessary, will send a specialist to determine just what methods you should use to get the best results. This Service is without charge.

**ATLAS POWDER COMPANY**
**Wilmington, Del.**

Branch Offices: Allentown, Pa.; Birmingham, Ala.; Boston; Chicago; Des Moines, Ia.; Houghton, Mich.; Joplin, Mo.; Kansas City; Knoxville; McAlester, Okla.; Memphis; Nashville; New Orleans; New York; Philadelphia; Pittsburg, Kans.; Pittsburgh, Pa.; Pottsville, Pa.; St. Louis; Wilkes-Barre.

ATLAS
EXPLOSIVES

# Five Years Shoveling Clay

The owner of this Conneaut SPECIAL Shovel didn't want to part with it even after five years' use. "It's the best I ever used," he said.

Five years of shoveling have left their mark on the tough second growth Ohio white ash handle —but the finely tempered blade has worn evenly and its edge is as keen as ever. It is still good for service, though it has outlasted two or three ordinary shovels.

Conneaut (Mikkola Patent) Shovels are not only made to last. Scientific design by men who have made a study of shoveling problems has actually made it possible for your laborers to move 17% more material per day—*without knowing it.*

Try a dozen Conneaut SPECIAL Shovels (Mikkola Patent) in your shoveling gangs for thirty days. If at the end of that time you do not consider they are worth every cent of what we ask for them, send us a check for what you consider they are worth and we will send you a receipt in full.

*Your Friends*

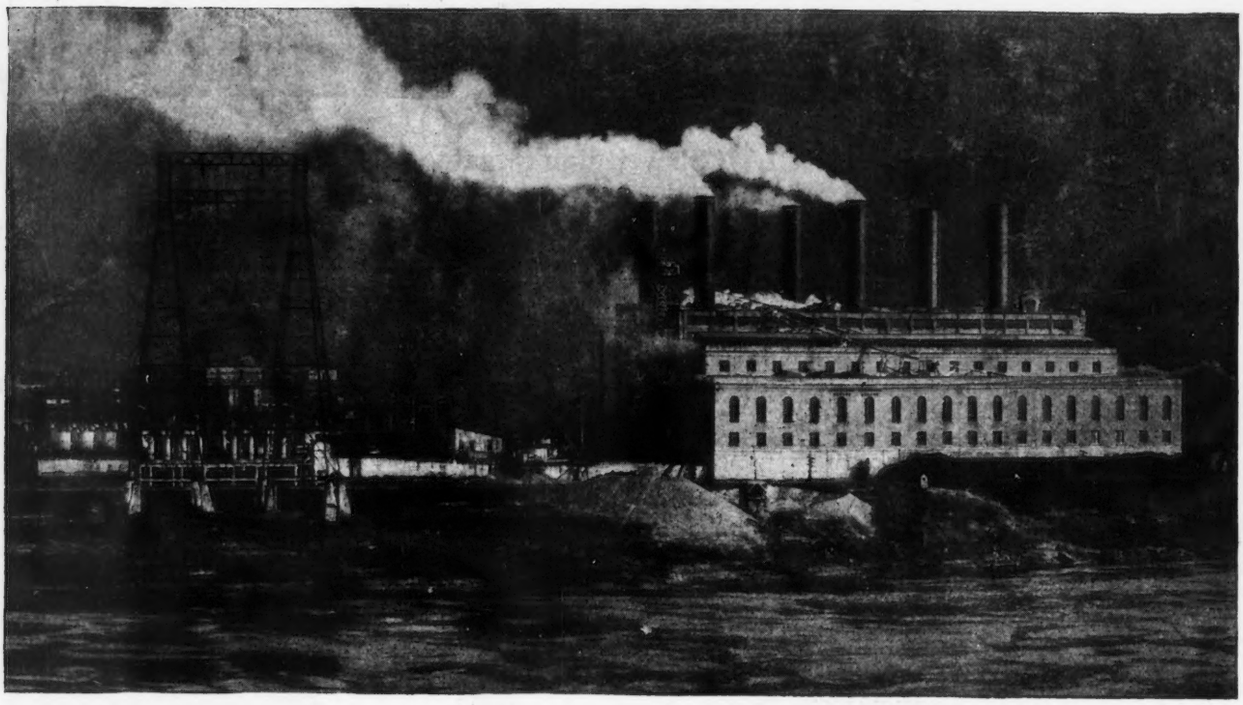
**The Conneaut Shovel Co.**

**Conneaut SPECIAL Shovels**

**Conneaut, Ohio**

**This Conneaut SPECIAL Shovel was used by a laborer in The Itner Brick Co., Belleville, Ill., for five years shoveling clay, yet it is still capable of service.**

## CONNEAUT SPECIAL SHOVELS



## 180,000 K. W. STEAM TURBINE GENERATING STATION
### American Gas & Electric Company, Windsor, W. Va.

The Windsor Power Plant consisting of a power house, two switch yards, an apparatus shop, and river-crossing transmission towers, is located about 9 miles above Wheeling, on the Ohio River.

The power house, 280 ft. x 300 ft. is of fireproof construction, all foundations being of reinforced concrete and the superstructure of steel and brick with steel sash and wire glass. A party wall parallel to the length of the structure divides the turbine room from the boiler room, the former having a width of 55 feet and the latter, 150 ft.

The present installation consists of four 30,000 kva., 11,000-V turbine-driven, alternating current generators. The boiler room contains four batteries of four boilers each. Two batteries are installed on each side of the boiler room, with a firing aisle between.

The water for the condensers and boilers is taken from the Ohio River through an intake tunnel, 13 feet wide, 24 feet high and about 90 feet by 20 feet, the bottom of which is 16 feet below low-water level.

There are two rectangular condenser pits, 25 ft. x 90 ft., with 6-ft. walls, each containing two condensers. The location of the condensers 56 feet below the basement level avoids excessive pump lifts.

The water from the plant is carried to the river by a discharge tunnel, 10 ft. x 11 ft. 6 in., which runs beneath the condenser pit and the screen chamber and empties into the river below the intake tunnel.

The superstructure, as well as the massive substructure of this plant were built by The Foundation Company from designs prepared by Messrs. Sargent & Lundy.

Three methods of foundation construction were used:

1. Steel sheet piling for tunnels, condenser pits screen chamber, and deep foundation piers.

2. "Ohio River" Cofferdam for river ends of intake and discharge tunnels.

3. Chicago Wells for shallow foundation piers.

BUILT BY

# THE FOUNDATION COMPANY

NEW YORK CHICAGO PITTSBURGH MONTREAL SEATTLE SAN FRANCISCO

EUROPEAN OFFICE: 16 Rue de la Pépiniere, Paris, France

**Highest Awards At:**

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|---|---|
| Bendigo, Australia | 1901 |
| St. Louis | 1904 |
| Portland | 1905 |
| Jamestown | 1907 |
| Seattle | 1909 |
| San Francisco | 1915 |

# BRAUN
## LABORATORY APPLIANCES

effect a saving in time and labor. They have a proven record of results in mine, mill and metallurgical laboratories in practically every mining district throughout the world.

ASSAYERS—These appliances will lessen your work, speed your operations and give more accurate results: "*Braun Chipmunk Crusher*"—"*Braun Sam'le Grinder*"—"*Braun Type U A Pulverizer*"—"*Universal Sampler*"—"*Braun Sample Mixer.*"

### FLOTATION

Every laboratory should be equipped to make flotation tests. This can be readily accomplished by use of the Braun K & K Laboratory Flotation Machine and Braun Laboratory Ball Mill.

We manufacture Mechanical disc feeders for oils and reagents.

Laboratory apparatus and supplies, chemicals and reagents, zinc dust, zinc shavings, cyanide and quicksilver.

*Write for catalogue and prices.*

THE BRAUN CORPORATION
Los Angeles, U. S. A.

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**Anaconda Model**

**Oliver Filters are built in Standard sizes from 3 ft. diameter x 6 in. up to 14 ft. diameter x 24 ft.**

**We willingly modify our standard machines to suit your mill conditions.**

**Whatever your tonnage, there is an Oliver made to handle it.**

At home, they are the choice of such great companies as Anaconda, Inspiration, Miami, Nevada Con., Cananea, Copper Queen, Arizona Copper, Old Dominion, Ray, etc.

These concerns base their choice upon *Oliver accomplishments*—upon certainty rather than guesswork. Write us about *your* requirements.

# IVER

# CONTINUOUS FILTERS

## Are in Active Demand for Service

# OVER-SEAS

[illegible] years ago. Its recent foreign sales include six 12-ft. diameter by 16-ft. Oliver filters, with complete vacuum equipment, to the American Smelter Securities Co. for its Veta Grande mill at Parral, Chihuahua, Mexico. Another Oliver installation in Mexico during 1918 was that of a 14 x 18-ft. filter at the mill of the Alvarado Mining and Milling Co. at Parral. During the present month the Oliver company is shipping duplicates of the Veta Grande filter to the Benguet Consolidated Mines, in Benguet, Philippine Islands, and another to a cyanide plant in the Dutch East Indies, which is being installed by the Netherlands government.

## OLIVER CONTINUOUS FILTER COMPANY

HOOKER & LENT BUILDING, SAN FRANCISCO, CALIF.

35 East 41st Street, New York City

# PHOTOGRAPHIC COPYING

# The PHOTOSTAT

(*Reg. U. S. Pat. Off.*)

## How One Mining Company Uses *The PHOTOSTAT*

All progress maps, new work, etc., are laid out either in pencil or ink, and the Photostat copies are given to the underground foremen and shift bosses.

The same thing is done with regard to stope maps, positions of pillars, etc.

The use of blueprints in the machine shop, foundry and other construction departments is practically discontinued.

In the office all deeds, leases, etc., are copied as soon as they arrive and the Photostat copy is sent to the home office for filing. This has the advantage of giving an exact copy of the original, with all changes, signatures, etc., faithfully reproduced.

## NEVER MAKES A MISTAKE

### The PHOTOSTAT is a Photographic Copying Machine

It is simple and practical, easy to handle and requires no expert knowledge.

The machine is loaded with a roll of sensitized paper especially manufactured for the purpose.

The original subject is photographed directly upon this paper producing a facsimile copy which is immediately cut off, developed and fixed right in the PHOTOSTAT itself.

The focusing, exposing and developing are all controlled by simple mechanical devices and no glass plate, film or other intermediate negative has to be made.

After fixing, the copy is removed to a tank of running water and rapidly washed free from chemicals.

It is then dried and is ready for use.

As many copies as desired may be run off in this manner.

By a simple adjustment of the mechanical focusing device the copy may be made at actual size, reduced, or enlarged, within the size limitations of the machine.

*Error in copy is impossible because every copy is an absolute facsimile.*

*The operations are all simple, such as a boy or girl can do.*

### The PHOTOSTAT Copies

**Pencil Drawings, Ink Drawings, Tracings, Reports, Shipping Lists, Data Sheets, Contracts, Ledger Pages, Illustrations for Salesmen, Cuts and Drawings for Advertising, etc.**

**Blue Prints, Sketches, Maps, Letters, Insurance Records, Graphs, Specifications, Legal Documents,**

**This cut shows a PHOTOSTAT on which a large drawing has just been copied in less than a minute.**

**Manufactured by the Eastman Kodak Company exclusively for the**

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**CHICAGO NEW YORK CITY PHILADELPHIA PROVIDENCE WASHINGTON**

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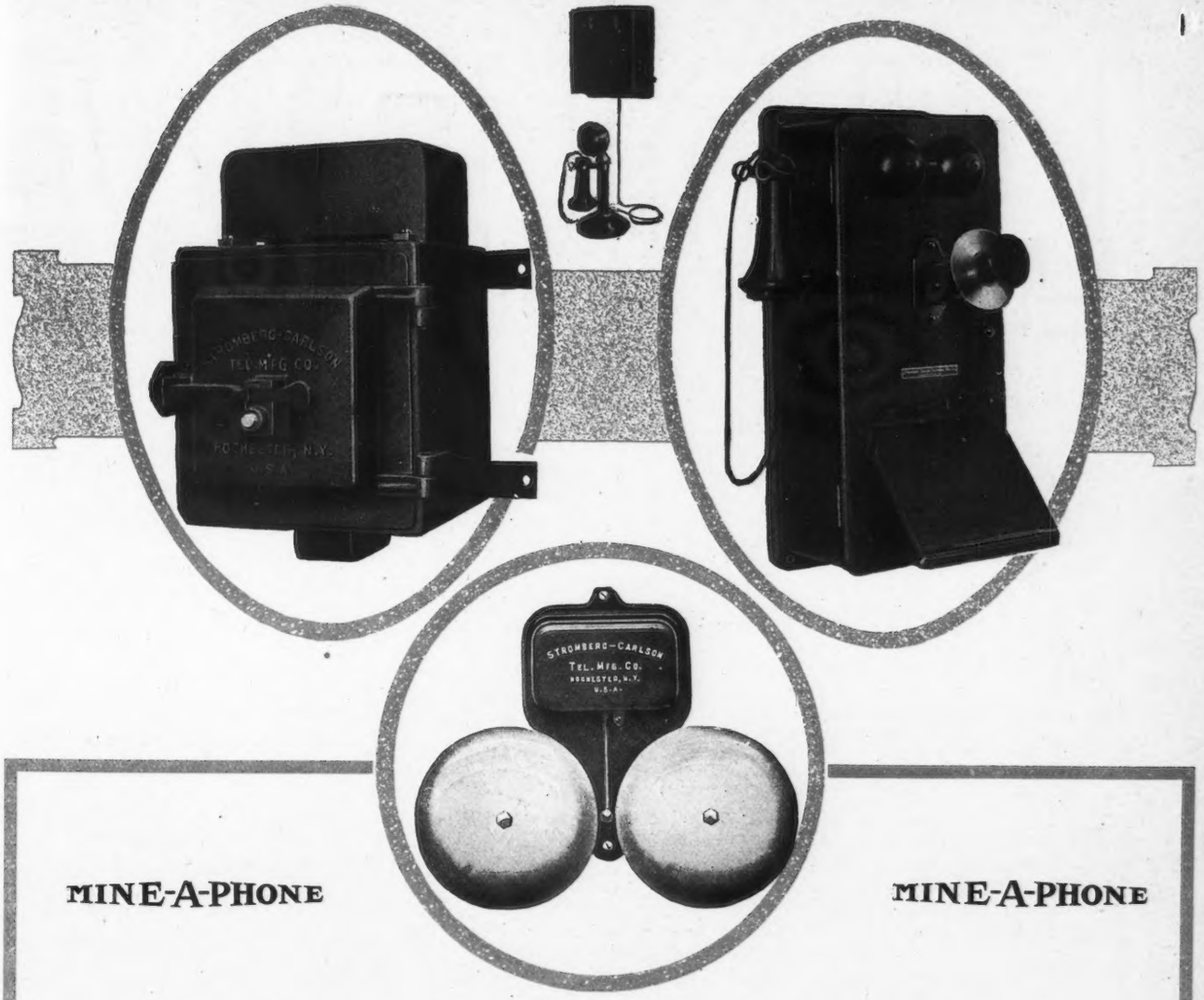



MINE-A-PHONE MINE-A-PHONE

# Let Us Supply Your Complete Mine Telephone Equipment

We have had over twenty-five years' experience in the business—specializing in the design and manufacture of telephones for all commercial purposes—therefore we know how to make them right so that they assure the maximum of efficiency and are always reliable.

We know the requirements of a telephone for mine service—know the severity of this class of service—and this knowledge and experience is exemplified in the complete system we can supply for mine telephone communication including the wall telephone—the desk telephone—the Mineaphone—the waterproof, loud ringing extension signal bells.

The Mineaphone has an international reputation for durability and reliability. It stands the rough service in the mine—it's rough and always ready. Dustproof — fireproof — gasproof — waterproof. Let us tell you about the high efficiency transmitter and receiver—and other points of advantage. Write today for quotation on complete mine telephone system.

**THE STROMBERG-CARLSON TELEPHONE MFG. COMPANY**

**ROCHESTER, NEW YORK**

**Chicago** **Kansas City** **Toronto**

Southern Distributors: Scoville Mercantile Company, Atlanta, Georgia. Pacific Coast Distributors: Garnett Young & Company, San Francisco, Calif. Wellington, New Zealand, Richardson-McCabe Co. Johannesburg, So. Africa, Herbert Ainsworth.

# LUDLOW—

YOU are keenly interested in lower milling costs—and improved efficiency in your ore dressing operations—economic conditions demand it today more than ever before.

There's big business to be done and your margin of profit with high labor and supply costs *depends on efficiency and demands greater effort toward lower production costs.*

Have you ever thought of wire screens for screen-sizing in the light of a highly specialized product demanding designing ability and careful fabrication for highest economy?—or do all screens look alike to you?

There's a big difference. Ludlow-Saylor "Perfect" Wire Screens *cost less* per ton of material screened—give you not an approximate, but an absolutely, *perfectly* sized product—and improve the performance of your ore dressing machines. Direct and indirect *savings* that you will appreciate.

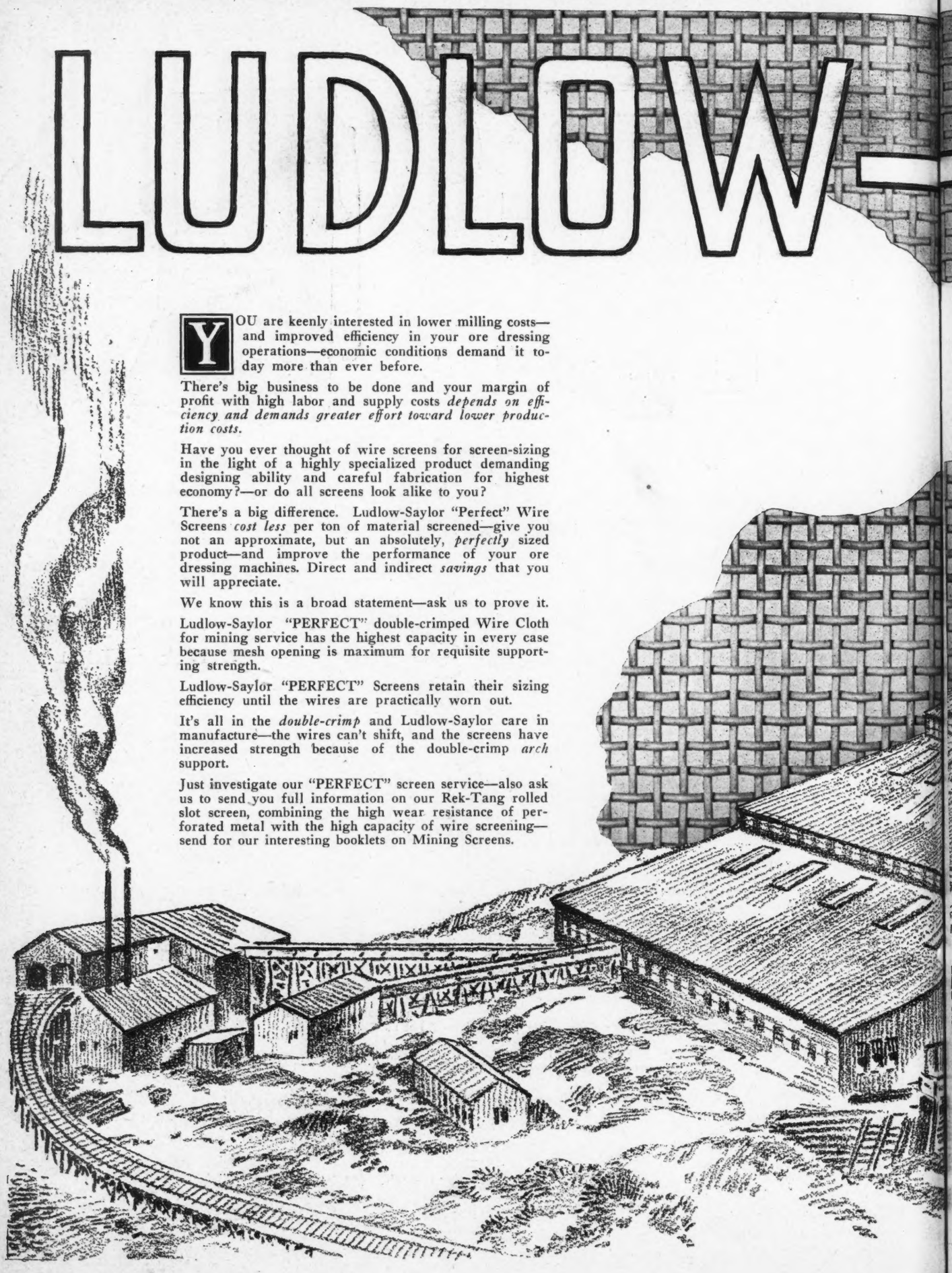
We know this is a broad statement—ask us to prove it.

Ludlow-Saylor "PERFECT" double-crimped Wire Cloth for mining service has the highest capacity in every case because mesh opening is maximum for requisite supporting strength.

Ludlow-Saylor "PERFECT" Screens retain their sizing efficiency until the wires are practically worn out.

It's all in the *double-crimp* and Ludlow-Saylor care in manufacture—the wires can't shift, and the screens have increased strength because of the double-crimp *arch* support.

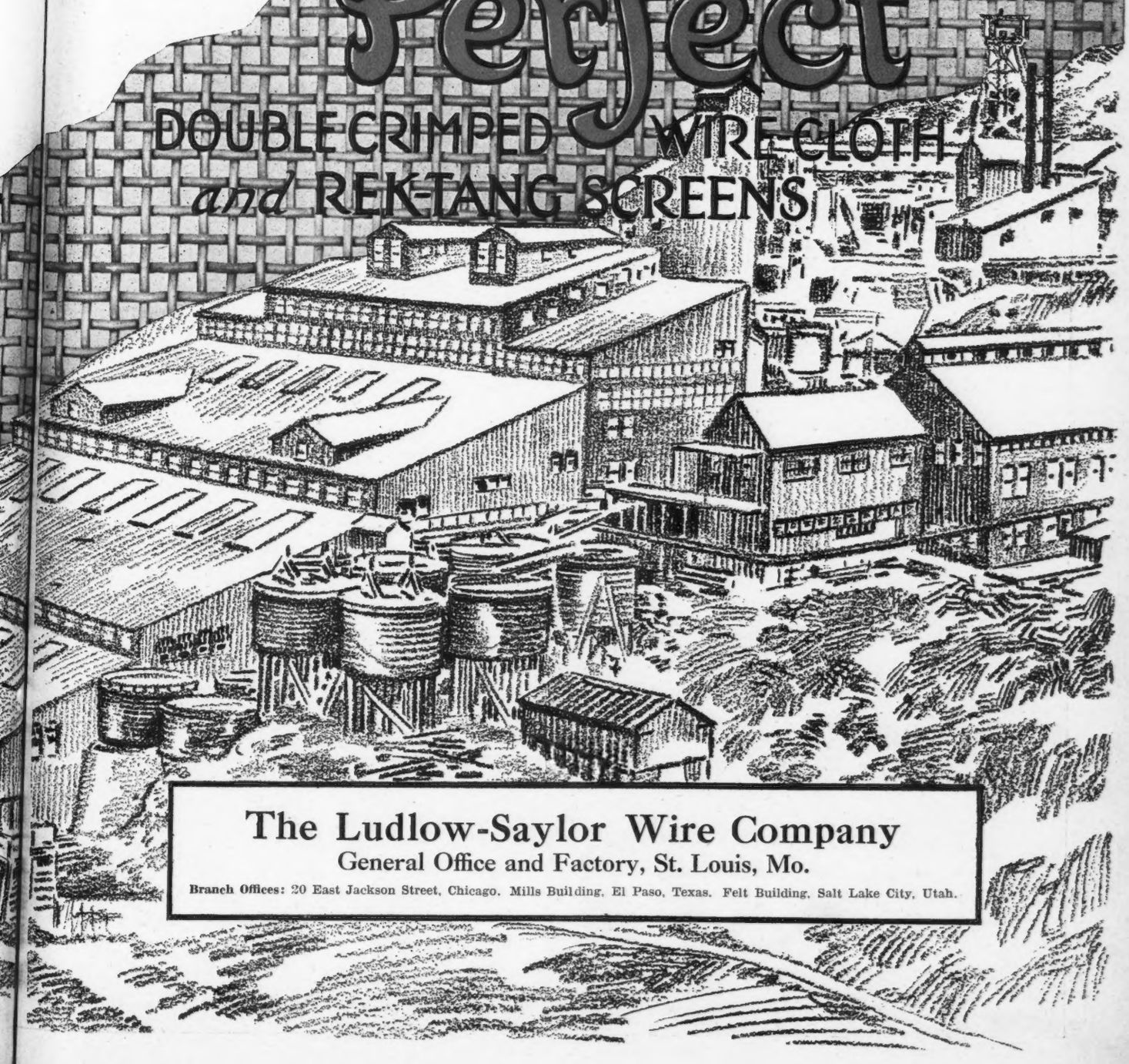
Just investigate our "PERFECT" screen service—also ask us to send you full information on our Rek-Tang rolled slot screen, combining the high wear resistance of perforated metal with the high capacity of wire screening—send for our interesting booklets on Mining Screens.



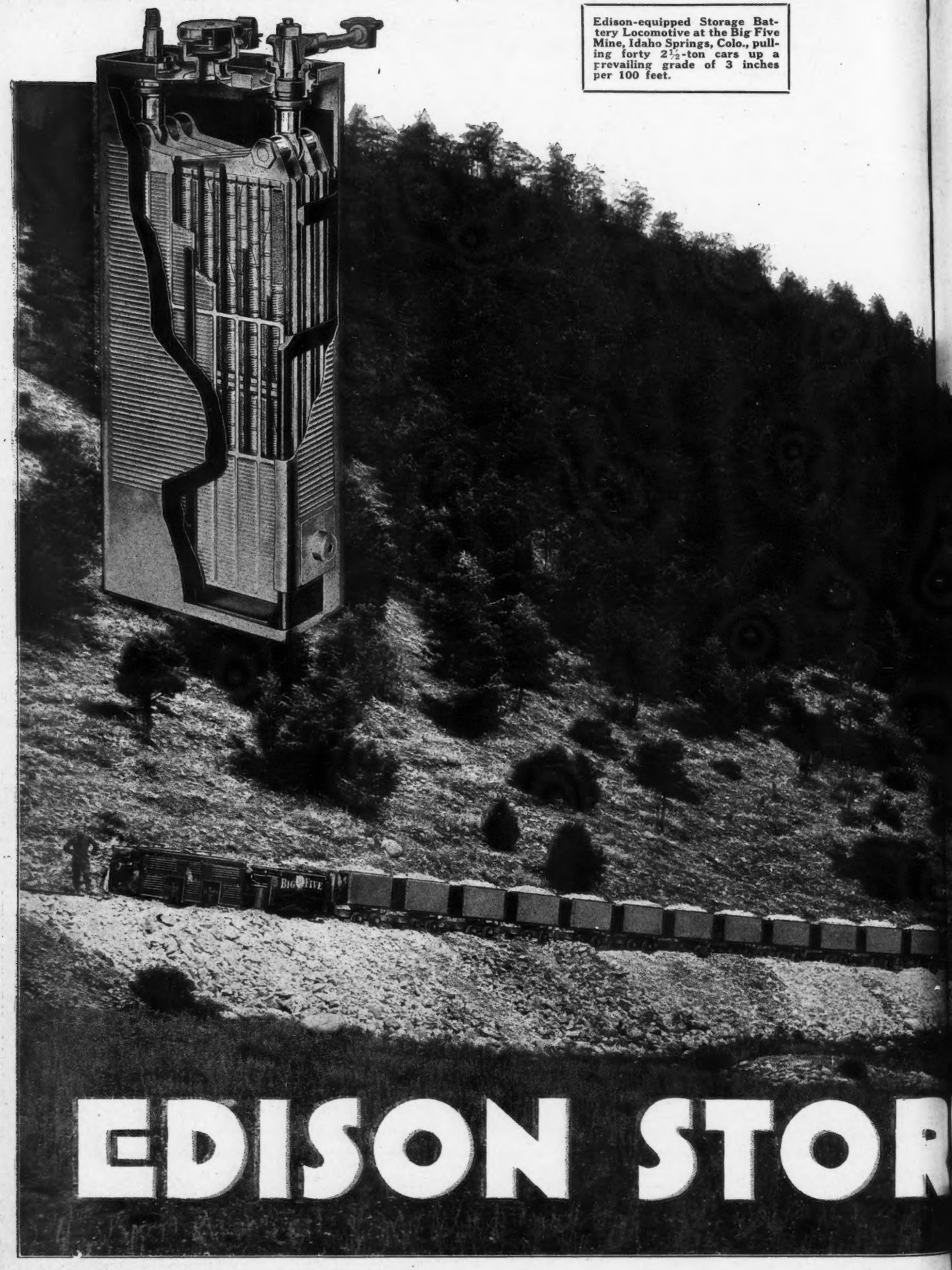
# SAYLOR

## "Perfect"

DOUBLE CRIMPED WIRE CLOTH
*and* REK-TANG SCREENS



**The Ludlow-Saylor Wire Company**
General Office and Factory, St. Louis, Mo.
**Branch Offices:** 20 East Jackson Street, Chicago. Mills Building, El Paso, Texas. Felt Building, Salt Lake City, Utah.




**Edison-equipped Storage Battery Locomotive at the Big Five Mine, Idaho Springs, Colo., pulling forty 2½-ton cars up a prevailing grade of 3 inches per 100 feet.**

# Over Seven Years in This Service Without Renewals

Since November, 1911, the Edison Storage Battery has been driving this locomotive.

During nearly eight years of constant service, the only repairs have been the replacement of a few small gland caps — the only attention, outside of charging, has been refilling the cells with distilled water and keeping the outside of cells clean. There have been no renewals.

The low maintenance cost is reflected in the cost of haulage, 5.96 cents per ton-mile; nearly 50% less than when horses were used.

It is the all-steel construction, permitted by the non-acid solution, which gives the Edison Storage Battery its great strength and endurance—it stands up! There is nothing about it to bend or crack.

**Insure continuous operation of your mine locomotives, with low operating cost. Specify the Edison — the only storage battery having any iron or steel in its construction.**

**Bulletin 608-C on request.**

## Edison Storage Battery Company

**Factory and Main Office:**
**Orange, N. J.**

**Distributors in**

New York
Boston
Chicago
Philadelphia
Detroit
San Francisco
Pittsburgh
Los Angeles
Seattle
New Orleans
Kansas City

# Don't Throw Money Away

Allowing pipe, structural steel work, mine cars etc., to rust and corrode prematurely—throwing money away—is quite expensive—and quite avoidable.

Perhaps you haven't looked at it in just that light before—repairs and replacements are made here and there, the work goes on just the same—but there's a big item on your expense account at the end of the year that could have been eliminated.

Charge it up to rust and to corrosion by acid mine waters this year—but *start now* and Highlandize this item off your next year's statement.

## HIGHLAND
### NON-CORROSIVE
## COATING

saves money every time, increasing the life of iron and steel from two to ten times or more.

Iron pipe dipped in Highland Non-Corrosive Coating receives a hard, impervious—and wear resistant coating, which will not chip or scale—frictional resistance is less, therefore pumping costs are lowered.

Highlandized concrete work and mine timbers last much longer than unprotected kind—there's an unlimited range of work for Highland Non-Corrosive Coating—write for information.

Highly resistant to electrolytic action.

**Highland Chemical Products Co.**
**Connellsville, Pa.**

Are You Reading Our Weekly Messages ?
Stop the Leak
THE DIAMOND DRILL CARBON CO.
Direct Importers of
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DO YOU FEEL LIKE CROWING
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Diamonds for all Industrial Purposes
The DIAMOND DRILL CARBON CO.

# THE BARTLETT HAYWARD CO.

***Founders and Engineers***

**Main Office and Works:**
**BALTIMORE, MD.**

**100 Broadway**
**NEW YORK CITY**

## PRODUCTS:

**Complete Plants for Coal and Water Gas, Coal Gas By-Products, Cane and Beet Sugar; Special Equipment for Gas and By-Product Plants; Special Gas Cleaning Apparatus; White and Middleton Gas Engines.**

## GAS MANUFACTURING PLANTS:

We design and build complete plants for the manufacture of
- Coal Gas
- Carburetted Water Gas
- Blue Water Gas

as well as **special equipment** for plants of any size
- DeBrouwer Retort Charging and Discharging Machines
- Hot Coke Conveyors
- Condensers
- Tar Extractors
- Scrubbers
- Purifier Boxes
- Feld Type Vertical Centrifugal Scrubbers
- Gas Holders
- Steel Tanks
- Waste Heat Boilers
- Coke Screening Plants

## SPECIAL GAS CLEANING APPARATUS:

We design and build special apparatus for cleaning the gas from
- Blast Furnaces
- Gas Producers
- Lime Kilns

## CANE AND BEET SUGAR FACTORIES:

- Multiple Effect Evaporators
- Vacuum Pans
- Crystallizers

## WHITE & MIDDLETON GAS ENGINES:

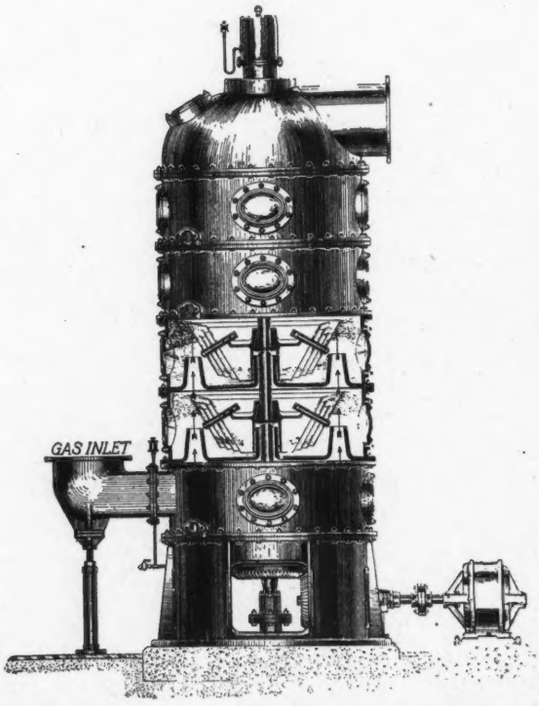
Horizontal Type—5 to 50 H.P.

## BY-PRODUCT PLANTS:

We design and build complete plants for the **manufacture** of
- Concentrated Ammonia
- Aqua Ammonia
- Ammonium Sulphate

and for the **recovery** of
- Tar
- Cyanogen
- Benzol and other products

as well as **special apparatus** for the
- Production of Ammonium Sulphate without the use of Sulphuric Acid.
- Manufacture of Potassium Ferrocyanide and Sodium Ferrocyanide

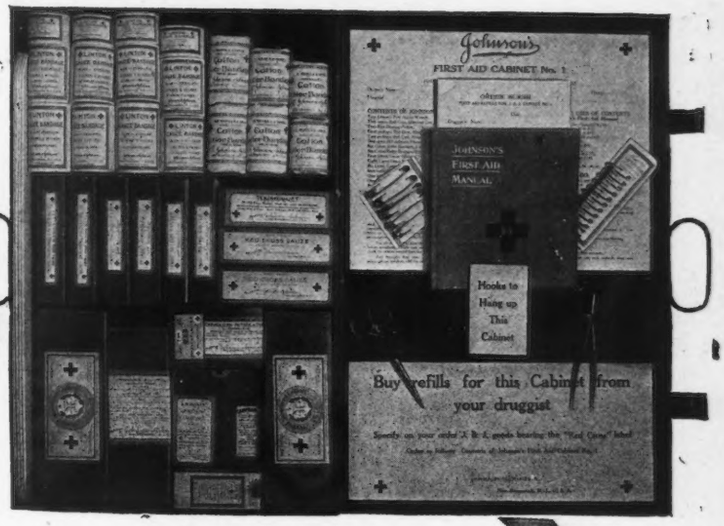



## BHCo-FELD TYPE GAS SCRUBBERS:

For dust removal and by-product recovery.

Scrubbers are built with diameter and number of sections to suit the requirements. Write for information.

# THE HELPING HAND MADE PRACTICAL


Johnson's
FIRST AID CABINET No. 1
JOHNSON'S FIRST AID MANUAL
Hooks to Hang up This Cabinet
Buy refills for this Cabinet from your druggist

Size 20 x 13 x 3½ inches.

# JOHNSON'S FIRST AID CABINET No. 1

makes the helping hand practical at first aid time—the time between the accident and the arrival of the doctor.

**Practical from a humane standpoint** because everything for the alleviation of pain and care of wounds is *within immediate reach.* Cotton, gauze, antiseptics, splints, bandages, scissors, etc., are conveniently arranged and plainly labeled. The entire outfit is as simple and complete as wide experience in first aid work can make it. The quicker the relief given, the quicker the recovery of the injured, because **quick relief** of suffering lessens loss of recuperative power.

**Practical from an economical standpoint** because *within reach* are the means to prevent wound-infection and consequent long lay-offs; to put one of your earning units back on the job quickly, and to keep down your accident liability.

**Practical from an emergency standpoint** because the cabinet *goes to the side of the hurt.* A strong-hinged metal case thoroughly protects the material, so that Johnson's Cabinet may be placed almost anywhere in the mine and always be ready to respond to the call "Help." Price? $9.00, F.O.B. New Brunswick. Can you think of a better investment?

**Order One Now—You May Need It Tomorrow**

Department No. 17

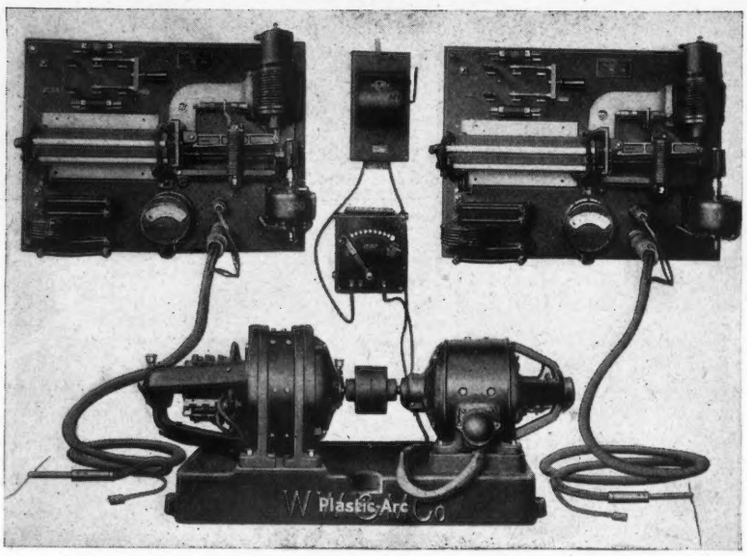
Johnson & Johnson
NEW BRUNSWICK, NEW JERSEY, U. S. A.

Department No. 17

# WILSON Plastic-Arc WELDER

(Trade Mark)

**The Wilson Plastic-Arc Welder will successfully weld any metal of practically any bulk, IN PLACE, without preheating (distortion), dismantling or annealing.**




Two-Arc, 300 Ampere Wilson Plastic-Arc Welder

A **Plastic-Arc** outfit is a ready repair tool in the case of damaged or broken parts of any machinery and should be a part of the regular equipment of every metal mine or smelter.

A predetermined, critical and constant heat at the weld eliminates the possibility of burnt metal or voids resulting in failure, common in welds when the critical heat cannot be controlled.

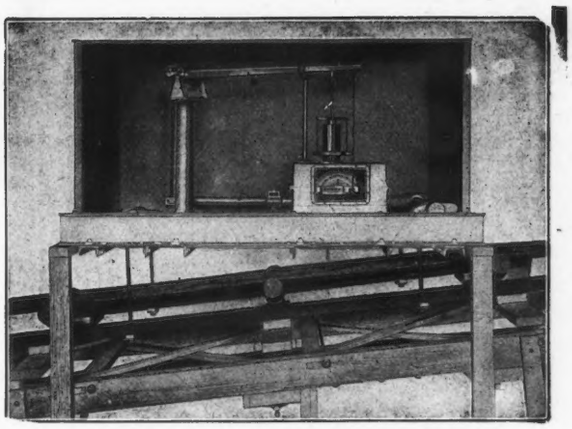
The welding metal electrodes used in **Plastic-Arc** welding are of several grades, and every coil carries our guarantee that it is the proper metal for the particular purpose for which supplied, and also that it is uniform throughout.

Our booklet, "Repair of the German Ships," tells the story of the repair of the 70 cast-iron cylinders and other parts of the interned German ships—the biggest welding repair job in the history of the world. Copies of this booklet and samples of our special certified welding metals (patented) will be supplied upon request.

## WILSON WELDER AND METALS CO., Inc.

**1 Rector Street, New York City**

# It tells——



**Write for Catalog A-11**

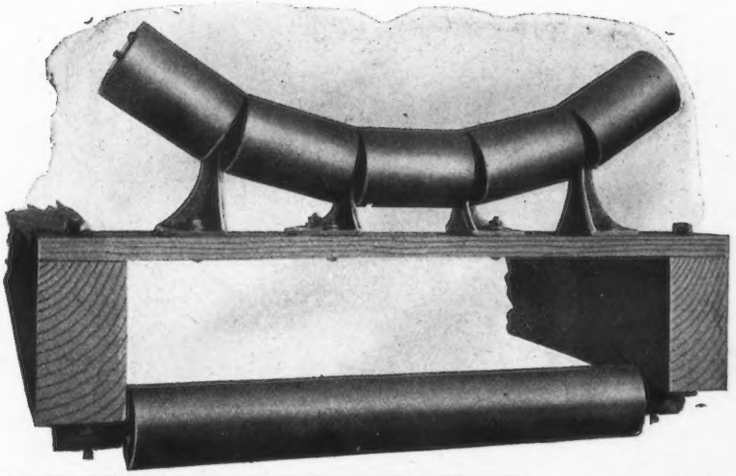
## The MERRICK Conveying Weigher

### *Tells Weight of Ores in Transit*

on a belt bucket or pan conveyor. It registers the *total* weight—traces a record of all the *variations* in the weight passed, no matter whether the load is continuous or intermittent.

It needs no attendant. Its accuracy is guaranteed to be within *one per cent.* Sturdy—dustproof—low in maintenance. *You need this equipment.*

# It saves——



*We are the original manufacturers of ball bearing idlers for belt conveyors. We'll gladly help you solve any conveying problems. Get in touch with us. Write today.*

## "CONWEIGH" Ball Bearing Troughing and Return Idlers

### *Save Power Conveying Ores*

by decreasing the friction loss to minimum. Run on high-grade ball bearings that will need only *one lubrication per year.* Applicable to any conveyor. Note the easy trough, and the general compactness of entire arrangement. Send us the width of your conveyor and the maximum load in tons per hour and our engineers will supply some striking figures. *Get our free trial proposition.*

## The Conveying Weigher Co., 90 West St., New York

AGENCIES: The A. M. Ellicott Co., 301 St. James Street, Montreal, Canada. Herbert Ainsworth, The Corner House, Johannesburgh, Transvaal. Victor M. Braschi, Mexico City, Mexico. Zimmer Conveyor Co., 82 Mark Lane, London, E. C., England. Union Construction Co., San Francisco, Calif.

## Owners' Records of

# 100,000-200,000-300,000 MILES

THE ultimate mileage of White Trucks is still unmeasured. Some have rounded out 300,000 miles. Many have run 200,000 miles. Hundreds, probably thousands, have passed the 100,000 mark—a very common White performance.

We have just published a book which tells of more than 400 White Trucks with operating records of 100,000 miles and over. These trucks are still giving good service today.

This book is the most convincing exhibit on the subject of truck durability that has ever been presented. It gives a new insight into truck economy through truck longevity. A copy of "100,000 Miles and More" will be sent to anyone interested, upon request.

## WHITE TRUCKS

THE WHITE COMPANY, *Cleveland*

# HINDLEY Worm Gearing for Mining Machinery

holds special advantages in a very great variety of applications—hoists, drives, elevators and conveyors, ore dryers, mechanical gas producers continuous filters, agitation tanks and for many other purposes.

Hindley gears permit high speed ratios and the use of smaller high speed motors and engines for any given service—here's a big factor in economy—they allow a more convenient disposition of motive power—and they eliminate the wear and tear on machinery due to vibration. Hindley gears are noiseless in operation.

The Hindley type gearing has greater tooth contact than the ordinary straight worm—greater depth of tooth—and wider face. They are therefore capable of handling unusually heavy loads and operating at high speeds with perfect safety and maximum efficiency.

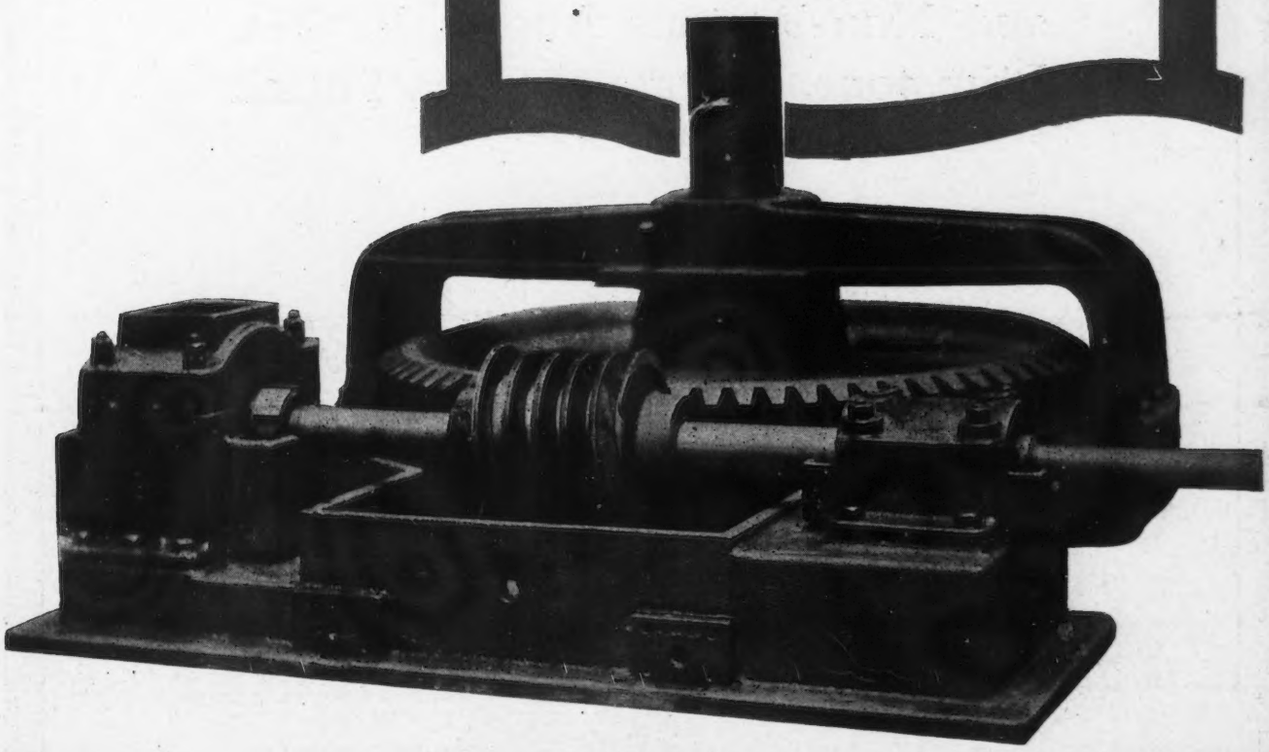
Here's a Hindley Gear (shown below) we are building for operating the paddles in cyanide tanks—and there's a Hindley gear fitted for *your* particular requirements—let our engineers tell you about them.

*Our new catalog No. 109 is full of valuable information and will be sent on application —write for it.*

**HINDLEY GEAR COMPANY**
**1105 Frankford Avenue**
**Philadelphia, Pa.**

HIGECO

**The Sign *of* HIGH GEAR EFFICIENCY**



# LUCIUS PITKIN
INCORPORATED
CHEMISTS AND ASSAYERS

**Weighers and Samplers**
**of**
ORES and METALS

**Specialists in**
**Gold, Silver, Copper, Lead, Ferro and Non-Ferrous Alloys, Pyrites, Brimstone, Nitrate of Soda, Potash**

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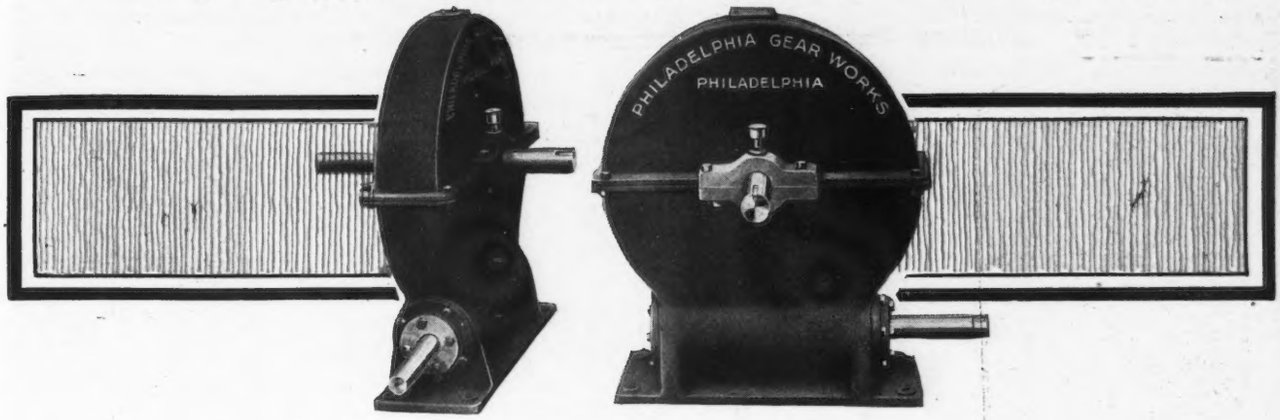
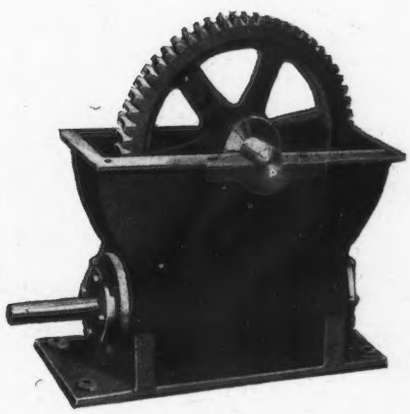
47 FULTON STREET
NEW YORK CITY




# Get In On P. G's Worm Gear Units

These housed worm gear units are furnished with plain or roller bearings, according to the nature of the service required, and with the worm either above or below the gear.

Ample lubrication is provided for in either case and smooth, silent, economical operation is assured.



Centers are accurately fixed and there is no possibility of the gears getting out of alignment. This prevents the accidental loss of power through excessive friction.

These units are furnished complete—worm, gear and housing fully assembled and tested—all ready to set up.

***When ordering, specify the center distance, power to be transmitted, speed of the worm and the reduction required.***

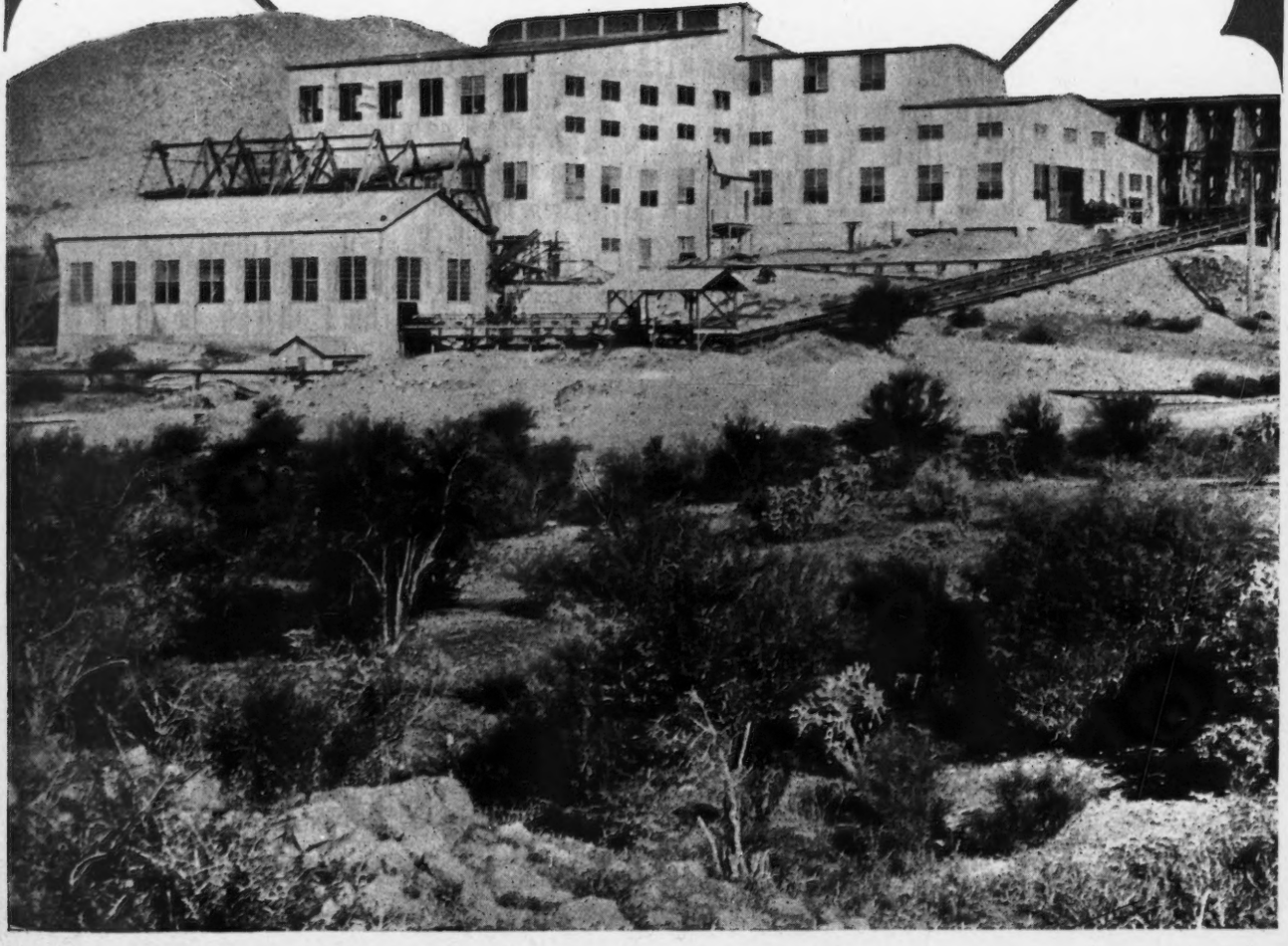
**Philadelphia GEAR Works** 1120-1128 Vine St. Philadelphia

*Complete*

# Mining and Metallurgical Installations

Power Plants
Powdered Coal Installations
Smelter and Refinery Design
Concentration
Cyanide and Flotation Plants

**Bradley, Bruff & Labarthe**
***Designing and Constructing Engineers***
**85 Second Street**
**San Francisco**



# From MINE To METAL

# Traylor Equipment

Traylor Engineering & Manufacturing Co.
Allentown Pa.

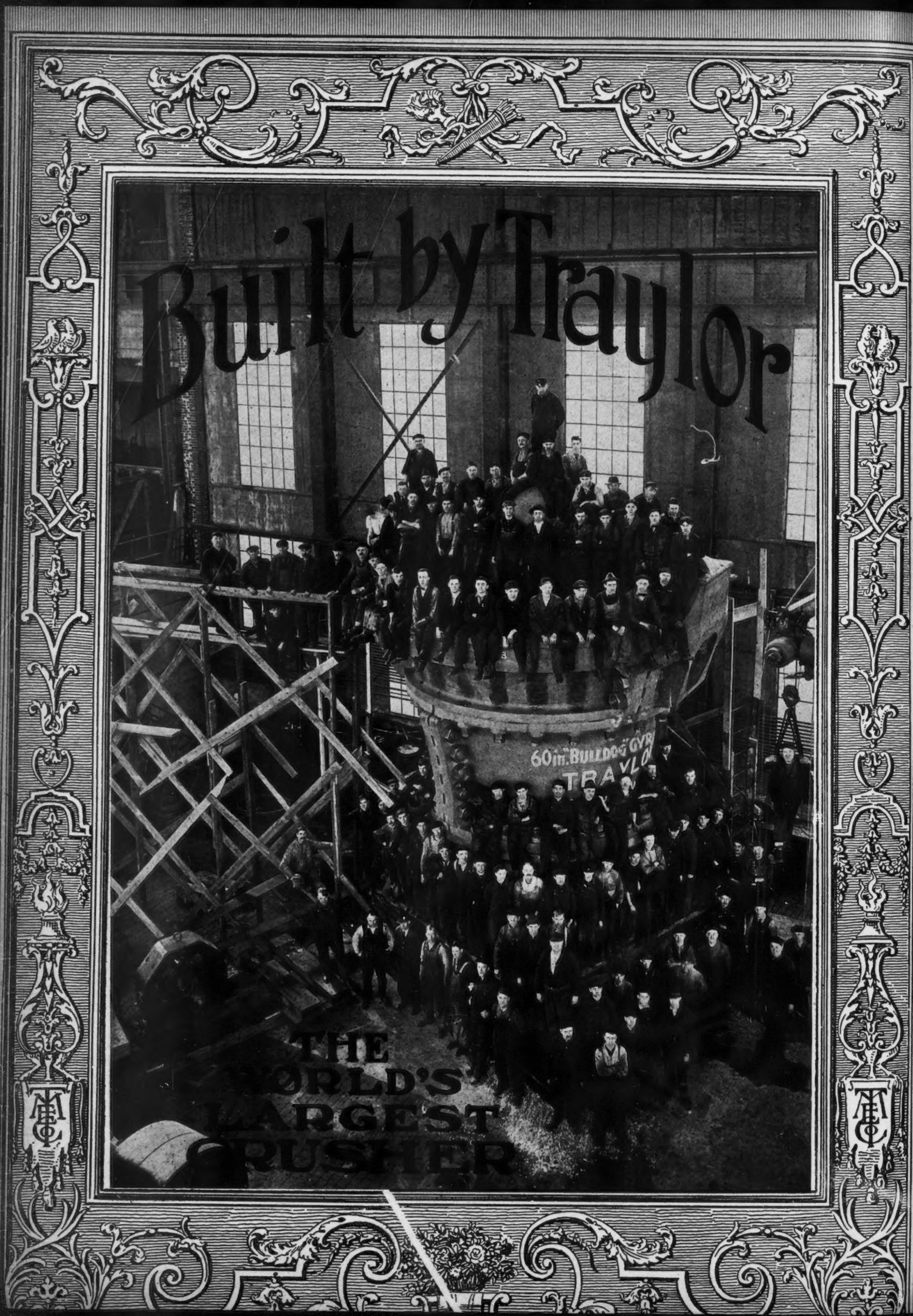
New York
30 Church St.

Los Angeles
Citizens Bank Bldg.

Chicago
Fisher Bldg.

Spokane
Mohawk Block

Jaw Crushers
Gyratory Crushers
Crushing Rolls
Ball & Tube Mills
Lead Smelting Furnaces
Copper " "
Copper Converters
Sampling Equipment
Sand Pumps
Mine Skips
Cement Machinery


Built by Traylor
60 in. BULLDOG GYR
THE
ORLD'S
ARGEST
RUSHER

# The Crusher Giant

AN interesting event in the history and development of rock crushing equipment has just been celebrated at the Allentown plant of The Traylor Company — *the completion of the world's largest crusher. This gigantic gyratory* weighing over 800,000 pounds has two receiving openings—each 60 in. x 190 in.—a capacity of 2500 *tons per hour* and is an achievement that marks an epoch in crusher practice.

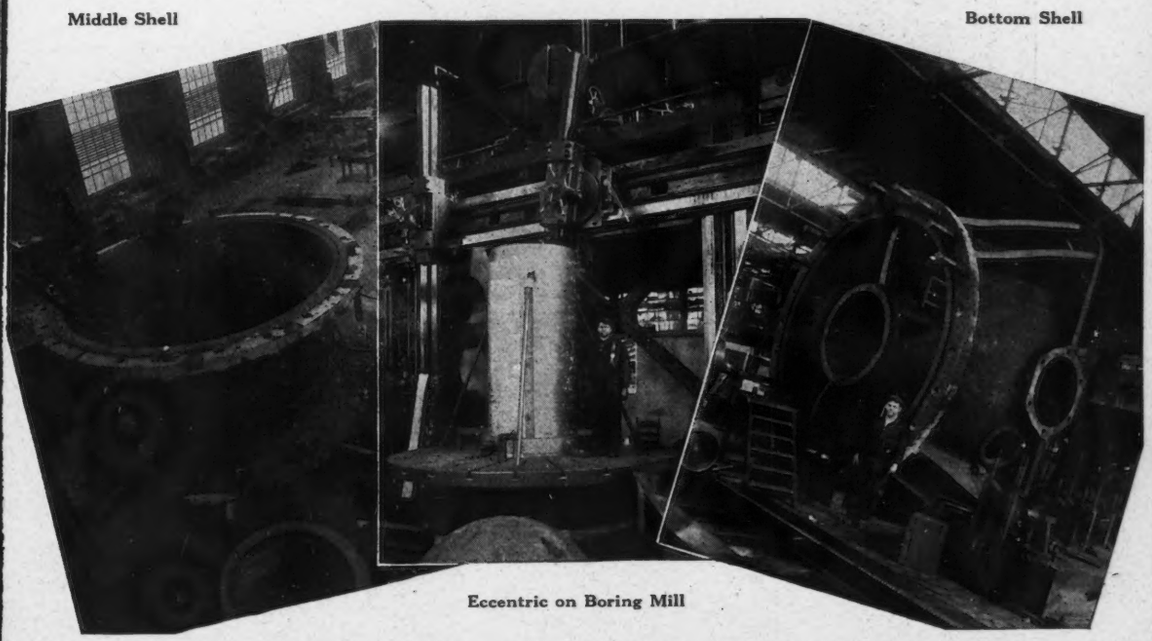
This "Traylor Giant"— a standard "Bulldog" Gyratory, with all the well known features of our smaller machines — has a shaft 21 ft. in length x 40 inches in diameter, weighing 56,000 lbs. The bottom and middle shells are immense castings weighing respectively 95,000 lbs. and 100,000 lbs. The enormous eccentric shown below in process of machining, will give some idea of the ample proportions. This crusher was built complete in $3\frac{1}{2}$ months — a feat made possible by our special plant facilities and long experience in the manufacture of crushing equipment.

A crusher of this enormous capacity, that "stands up" under the strains of an unusual service day-after-day — that operates continuously without over-heating — that eliminates the usual gyratory troubles and out-of-service-for-repair difficulties — means low cost crushing — higher tonnages — and reduced mining and quarrying costs — in short, greater efficiency all around.

We will gladly send you an outline of the quarry operations for which this "Traylor Giant" was built — it's interesting information that may suggest an opportunity for lower tonnage costs in *your own* plant — write to the nearest Traylor office for particulars.

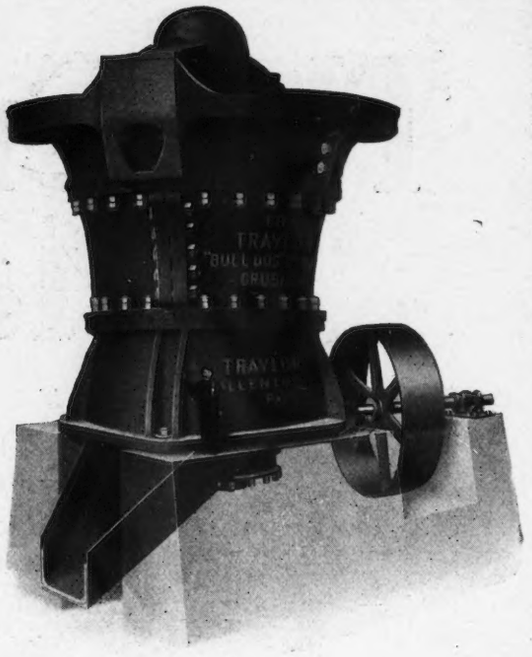
Middle Shell

Bottom Shell

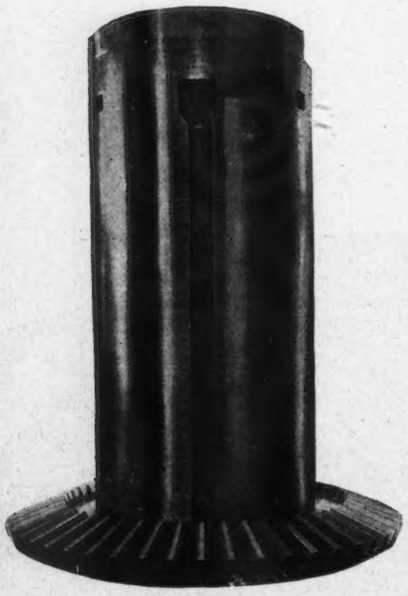


Eccentric on Boring Mill

# TRAYLOR "BULLDOG" GYRATORY CRUSHERS



with Traylor "Bulldog" Jaw Crushers, Heavy Duty Rolls, Ball Mills and Tube Mills meet the demand for greater crushing economy — Traylor crushing equipment is designed and manufactured with two basic ideas in mind — lower costs of rock breaking — and increased operating profits. Traylor success is *your* success.



Eccentric for 60 in. "Bulldog" Gyratory
Weight 20,000 lbs. Size 5 ft. x 9 ft.

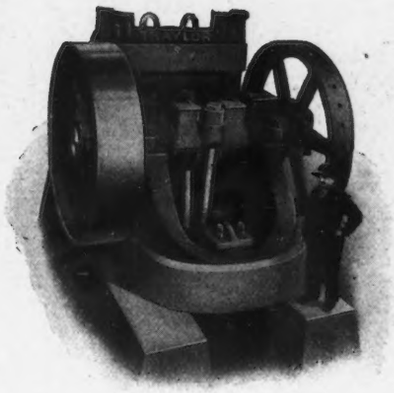
TRAYLOR "Bulldog" Gyratories are the result of evolution — forty years' experience — steady improvement in construction details — better and stronger materials. The many special features our gyratory crushers have, in aggregate, secured for them an unequalled reputation for freedom from maintenance troubles and expense — for low power costs — for economy.

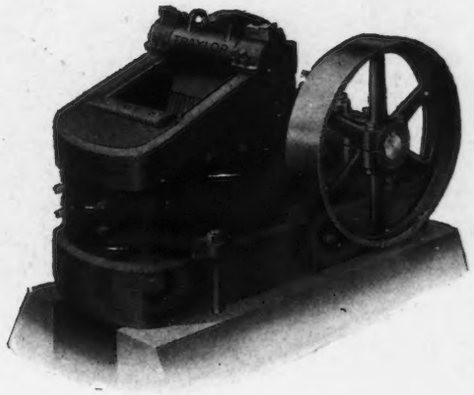
The "Bulldog" gyratory shaft is critically proportioned to insure great rigidity — it's shorter and 100% stronger than the usual gyratory shaft and suspended by a perfect all-steel rolling-motion suspension.

The "Bulldog" eccentric is larger and longer than others — reducing the pressure per sq.in. on the bearing surfaces — it is lubricated by forced feed oil circulation arranged to eliminate all chance of gritty matter getting in the bearings. Traylor Gyratory eccentrics remain cool under the hardest service and operate for years without rebabbitting.

"Bulldog" Gyratories are fully described in Bulletin GX-1.

Top Shell of 60 in. "Bulldog" Gyratory—Weight 115,000 lb.
Size 20 ft. x 20 ft. x 7 ft.





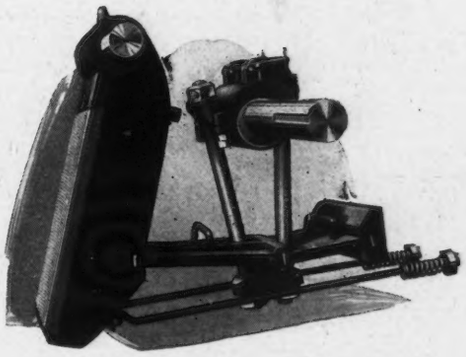
# TRAYLOR "BULLDOG" JAW CRUSHER

THERE'S a fascination about "the world's largest" — of anything — aside from the economic factors, and the world's largest jaw crusher naturally created much interest in the mining world two years ago. We are now duplicating this crusher, the 66 in. x 86 in. Jaw Crusher, regularly — equipped with the latest Traylor improvements — it has *proven* the low cost, high capacity rock breaker for exceptionally heavy continuous service.

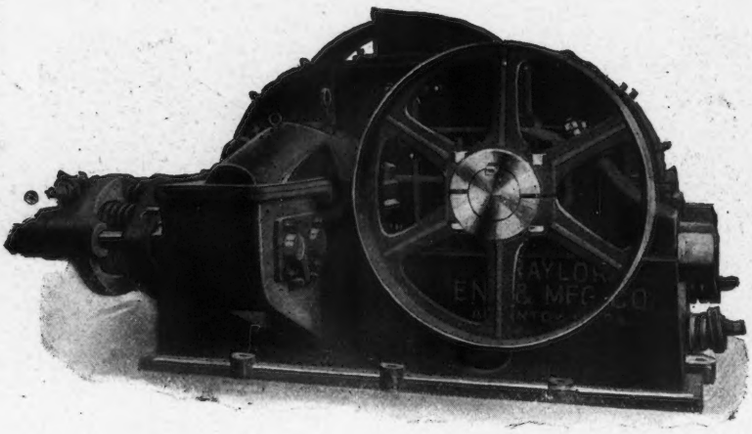
All Traylor "Bulldog" Jaw Crushers are built with our patented steel-band reinforced frame — having a greater tensile strength than any other crusher made.

All Traylor "Bulldog" Jaw Crushers have the new and improved pitman, here illustrated — a departure in crusher design — it's the *lightest* and *strongest* pitman construction known.

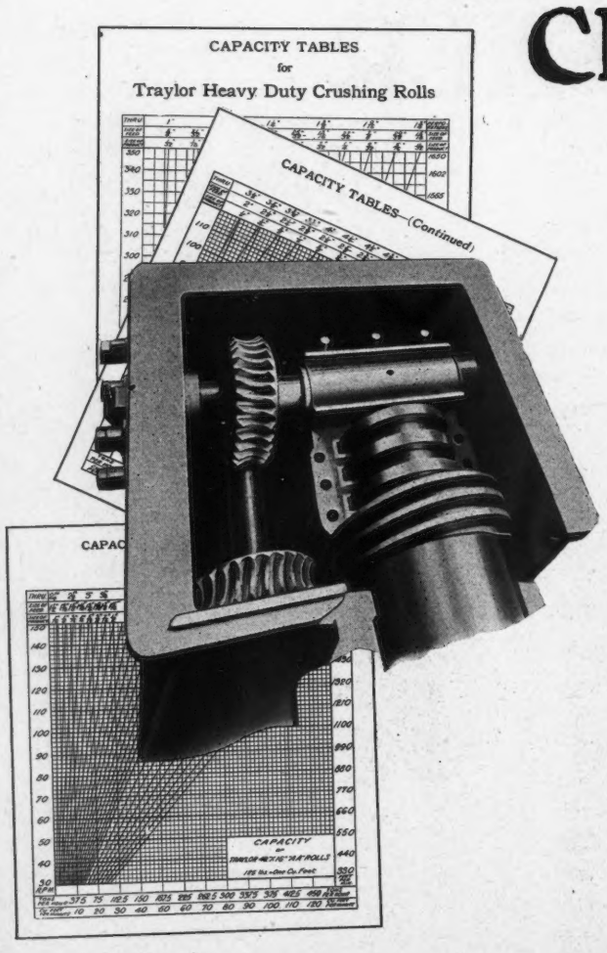
Traylor "Bulldog" Jaw Crushers with their frictionless toggle system and positive force-feed lubrication require less power per ton — and cost less for upkeep — send for Bulletin JX-1.



The "Bulldog" Toggle System



# TRAYLOR HEAVY DUTY CRUSHING ROLLS




THE striking characteristics of all Traylor Equipment — distinctiveness in design and construction for greater service — were first exhibited in Traylor Heavy-Duty Crushing Rolls with the *"fleeting roll"* or automatic lateral shifting device — a *decided* advance in roll design insuring more efficient work and lower maintenance costs per ton of material crushed.

This "fleeting roll" or lateral shifting mechanism — the simplest means known for preventing corrugating and flanging of the roll shells — operates positively so long as the rolls are in operation and keeps the shells in perfect condition.

Other features are the extra large, full inclosed bearings babbitted with the best grade of babbitt—the rigid shafts—the perfectly adjusted tension springs giving the highest possible roll pressure while eliminating the possibility of damage from tramp iron —and the simple end adjustment for roll clearance—features which "stand out" in Traylor Roll performance.

Our Bulletin R-2 contains much valuable information—and a set of capacity tables that you ought to have. Write for Bulletin R-2.

THE Traylor Organization — highly trained technical staff — skilled workmen in every department — ample plant facilities — new and up-to-date shops and equipment — enables us to undertake the manufacture of special machinery — unusual pieces — heavy castings, machine work, all kinds of plate work including tanks, bins, water jackets, etc., with promptness and guaranteed satisfaction.

We completed our "Traylor Giant" in three and one-half months from design to assembly — and last year, three and one-half months after receiving blueprints and specifications, the first 1400 H.P. Marine Engine completed in the United States for the Shipping Board—one of a large order, left our works.

Let us know your requirements, our Engineers will be glad to help you — we design, build and erect complete crushing plants — ore dressing plants — copper and lead smelting works — or any single piece of equipment that goes into them.

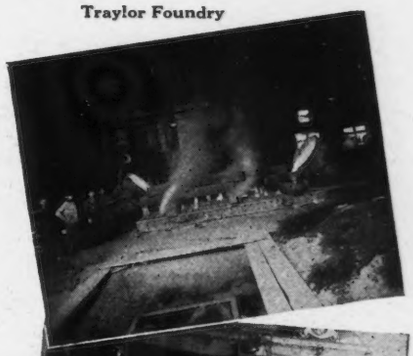
A telegram to the nearest Traylor office will bring complete information on Traylor service — our reputation extends throughout the mining world.

# Traylor Engineering & Manufacturing Co.

**Main Office and Works:**

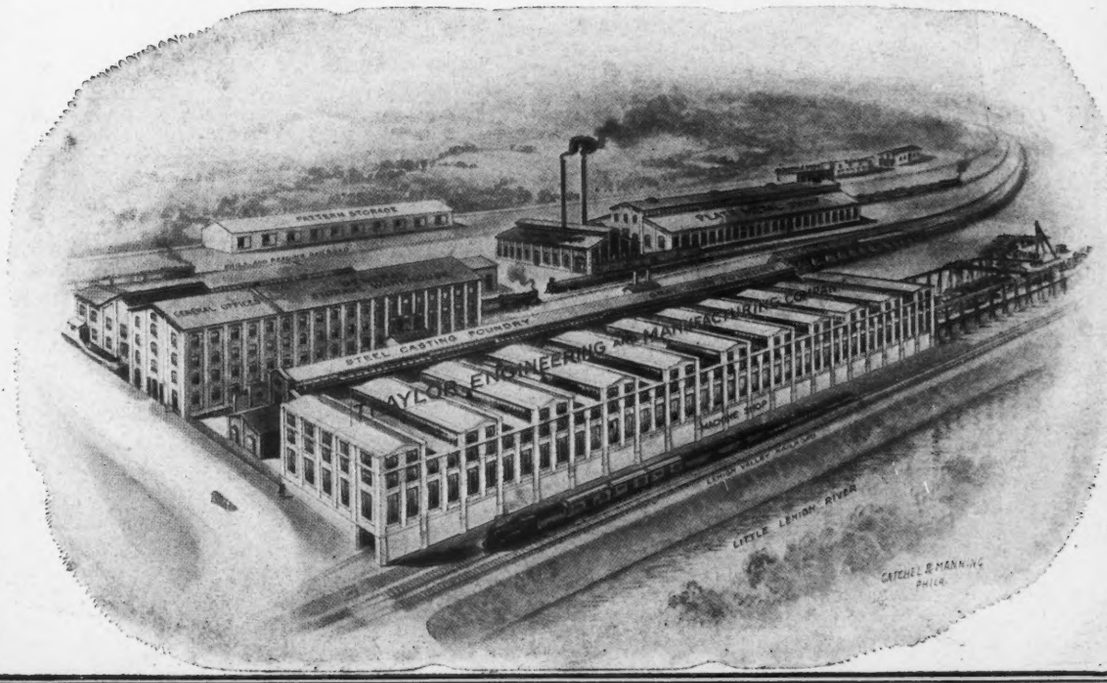
**Allentown, Pa., U. S. A.**

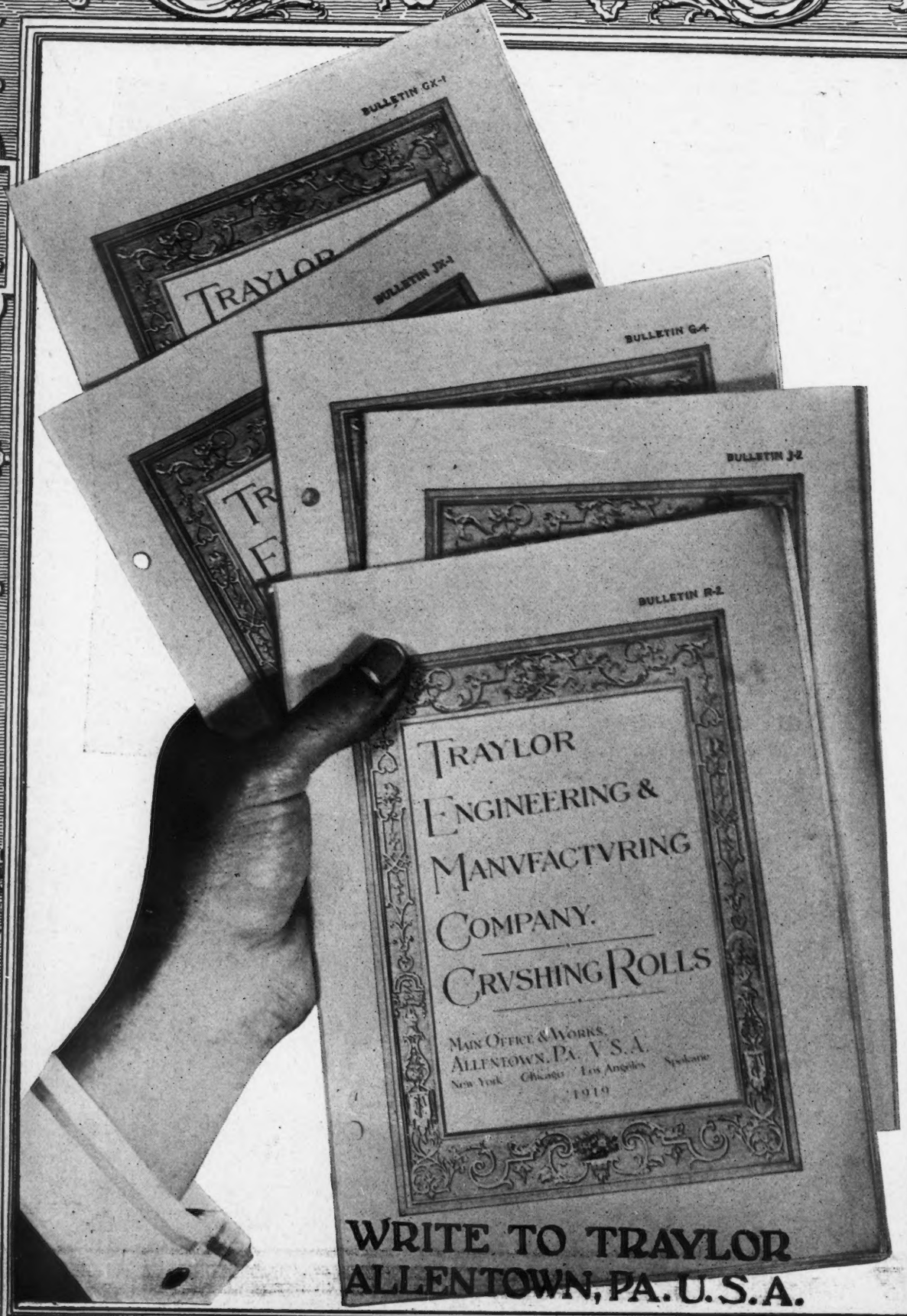
Traylor Foundry



Boiler Shop

Assembly Floor





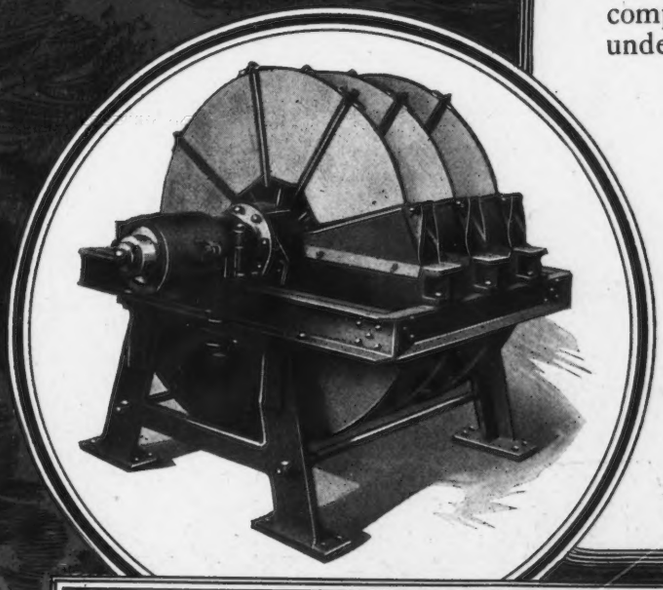

**WRITE TO TRAYLOR**
**ALLENTOWN, PA. U.S.A.**

Hawker's plan

across the Atlantic was balked by

A CLOGGED FILTER

Technically speaking, the rate of flow through the circulating water filter was so reduced by clogging of the filter medium that he was unable to complete the journey he so gallantly undertook.



Many industrial enterprises are also defeated by inefficient filters.

If you want to *get across* with successful chemical processes you must have efficient up-to-date Filters, and that means ***United Filters.***

**Send us your filter inquiries. We supply the filters that are used by the most successful progressive manufacturers.**

# United Filters

## CORPORATION

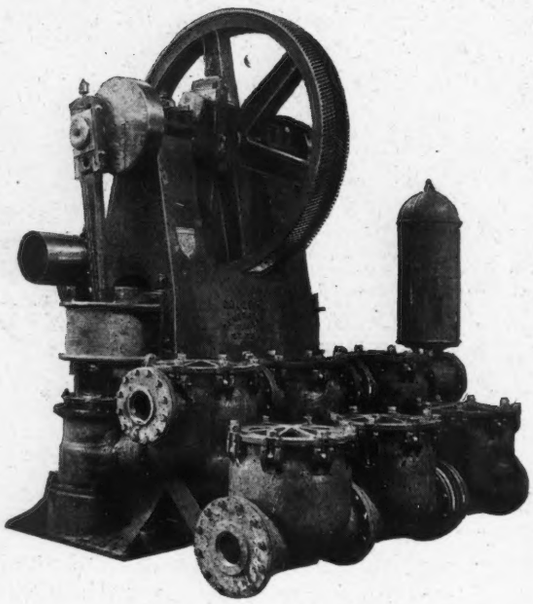
KELLY and SWEETLAND PRESSURE FILTERS AMERICAN CONTINUOUS FILTERS
SWEETLAND'S PATENT METALLIC FILTER CLOTH

HOLLINGSWORTH BLDG. LOS ANGELES, CAL.

65 BROADWAY, NEW YORK
Felt Bldg. SALT LAKE CITY, Utah

PEOPLE'S GAS BLDG. CHICAGO, ILL.

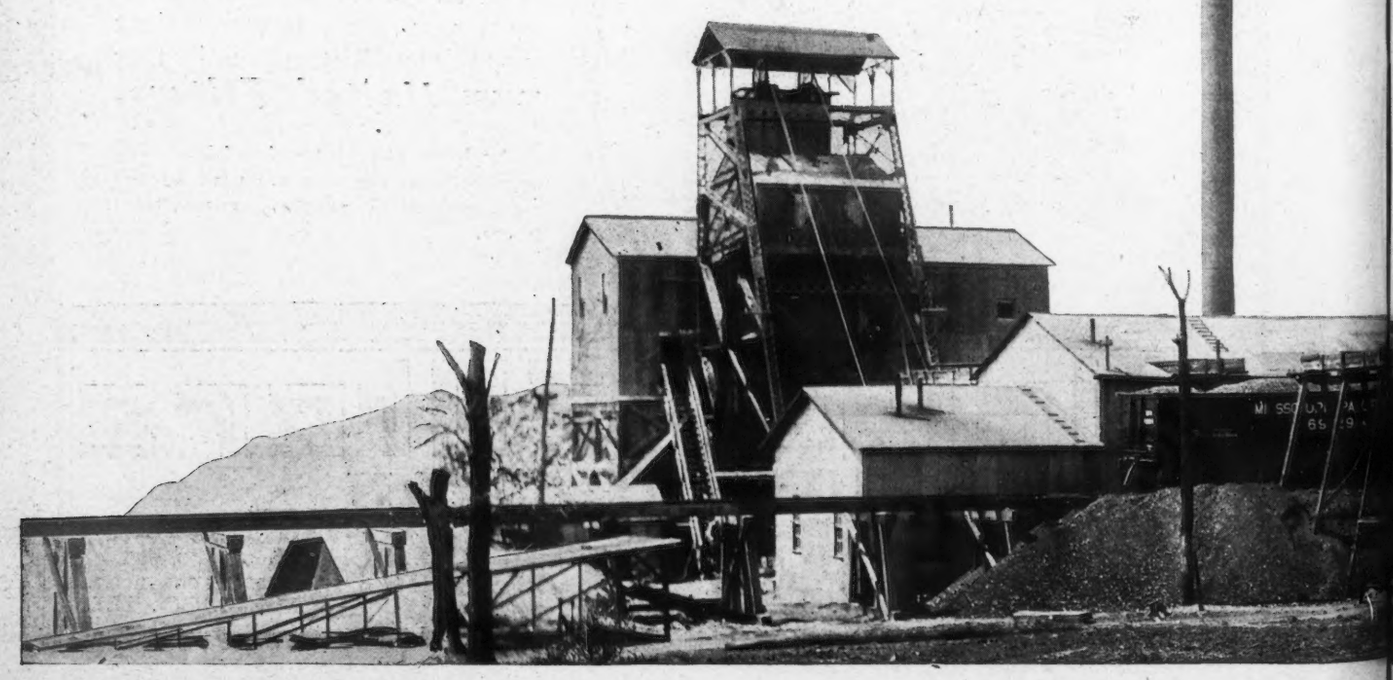
# The Guardians of Mining
# FALK Herringbone



Guardians for safety and for economy—in first cost, power consumption and operating charges. FALK herringbone Gears accurately hobbed from solid blanks eliminate the shock and vibration of spur gear drives—they distribute the load evenly over several teeth instead of one—and give a smooth, continuous power flow.

FALK herringbone Gears are *safe* because the bending moment on any one tooth is less than half that of a spur gear—and crystallization of the metal prevented due to the substitution of *continuous impulse* for "gear hammer."

FALK herringbone Gears are *economical* because the Wuest *stepped tooth* design insures equalized wear on gear teeth—every tooth retains its correct involute form through years of service—therefore an old *Falk* gear is just as efficient as when first installed—a big saving in operating costs.



# Machinery GEARS

**FALK herringbone Gears, for mine hoists, pumps, compressors, turbines, and general mining machinery—save power — and increase safety—they are decidedly economical.**

***Send for our bulletins and catalog.***

**THE FALK COMPANY**
**Milwaukee, Wis.**

AGENTS: Pittsburgh — W. O. Beyer, 1024 Park Bldg. New York — M. P. Fillingham, 50 Church St. Wilkes-Barre—Vulcan Iron Works. Denver—Denver Engineering Works. San Francisco — F. W. Grimwood, Rialto Bldg.

# FLORY MINE HOISTS

## Deep-Mine Hoisting Engineers

Perched on the operating platforms, their movements dictated by the clanging of a gong, are the hoisting engineers The ease with which they operate the massive hoisting engines of the iron and copper mines gives but slight indication of the responsibility that rests upon them in the performance of their duties. Carelessness on their part can cause a vast amount of damage, let alone the maiming and killing of the miners If you were to step on the man skip to be lowered more than a mile below the surface of the earth, it is ten to one that there would be visions of a broken cable followed by a funeral and flowers It is more than probable that the hoisting engineers would not be given a thought And yet the life of every man that goes down into a mine is in their hands They hoist hundreds of miners thousands of feet every day and think of it as merely a part of their day's work They are cool, intelligent, and are the right-men in-the-right-place engineers.

## No wonder they prefer the FLORY HOIST

"Intelligent * * * right-men-in-the-right-place engineers"—no wonder they appreciate its absolute dependability, its convenience from an operating standpoint, its simplicity, its speed, and the numerous other advantages for which it is noted.

**S. FLORY MFG. CO.** 95 Liberty Street, New York **BANGOR, PA.**

# POWER

## The great common problem in mining and milling

PRACTICES of mining and milling vary with locality and ore. But in EVERY mine and EVERY mill, there is the great common problem of economical and efficient POWER.

In simple concentrating power represents from 8 to 10% of the total cost; in all-sliming and other processes, it is not unusual for power to represent 20% of the total cost of the milling operation.

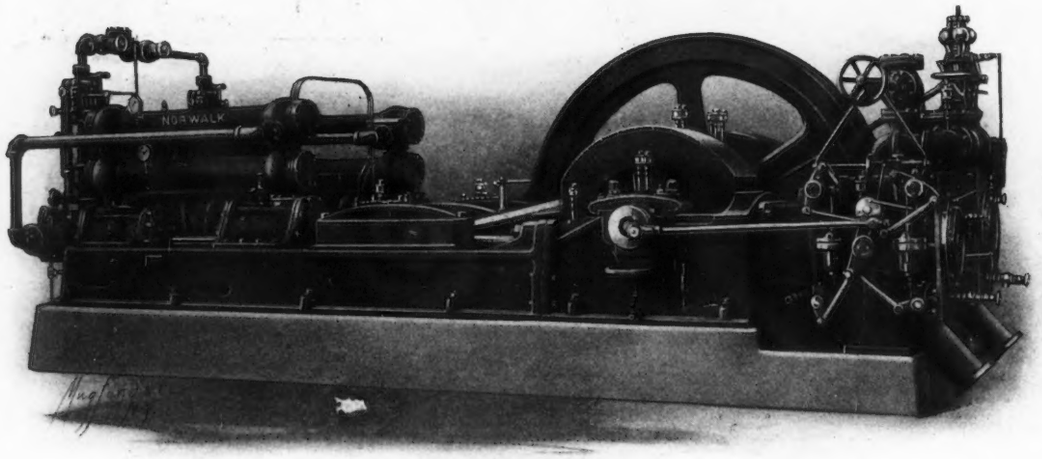
Haulage, rock breaking, conveying, screening, elevating, roll and fine crushing, classification, jigging, concentrating, thickening, agitation, filtration, sampling, pumping—ALL require POWER.

The progressiveness of the American manufacturer has placed unexcelled opportunities of realizing complete power plant efficiency and economy within your grasp.

Watch your power costs! The economical generation and utilization of power challenges the best there is in mine and mill operator.

NORWALK AIR & GAS COMPRESSORS

*Any capacity* *Any pressure*




# *You Are Sure of Your Results With a Norwalk Compressor*

THERE is a great deal more to satisfactory compressor service than the selection of a machine rated for the desired pressure. There is, for example, the highly important matter of economy—and equally worthy of notice is the factor of durability. The compressor which gives the expected pressure only with disproportionate operating expense, or which does not prove its durability in continuous work, is a costly and uncertain investment. And the time to consider these risks is *before you buy.*

The whole country is dotted with satisfied users of Norwalk Compressors—and some of them have been our patrons for upwards of forty years. Under the circumstances, we believe you will agree with us in saying that there can be no guesswork about what you get when you purchase a Norwalk. There are users in every State ready to support our claims of exceptional reliability, strength, economy and long life for Norwalk Compressors—*and they know.*

Norwalk Compressors are made for all compressing requirements—in any size and for any pressure.

*Let us send you full details on the Norwalk Compressors in which you are interested. Bulletins on machines for air, oxygen, hydrogen, acetylene gas or carbonic acid gas are at your disposal. Tell us which ones to mail.*

## The Norwalk Iron Works Company

*Pioneer Builders of Compressors*

South Norwalk, Conn.

# For Heavy Belts

the advantages of "Holtite" Belt Fasteners are obvious and unquestionable. On the pulley side their bolt-heads are completely imbedded on a level with the belt surface and pass over pulleys without "bump" or jar of any kind.

On the outer side of the belt, the fastener presents a smooth surface with beveled edges that cannot catch either the clothing of a workman or other objects that may come in contact with the moving belt.

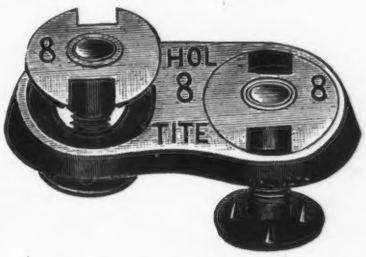
Large diameter flat head bolts, each with four sharp-pointed teeth, hold the belt with a grip that is as strong as the belt itself.

For permanent use, and 100% service, specify

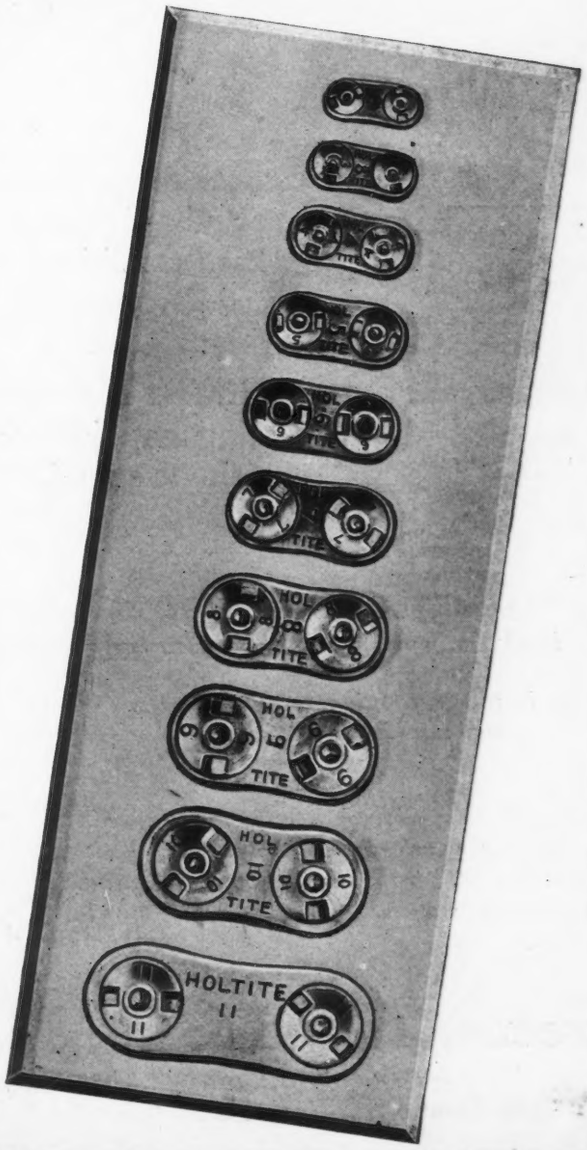
# "HOLTITE"
## BELT FASTENERS

This is the wrench that is used for screwing the nuts up tight—so tight that they are flush top and bottom as illustrated below.

The sectional view above shows why "Holtite" fasteners pass smoothly over pulleys—they don't touch the pulleys; therefore cannot "bump" or jar.

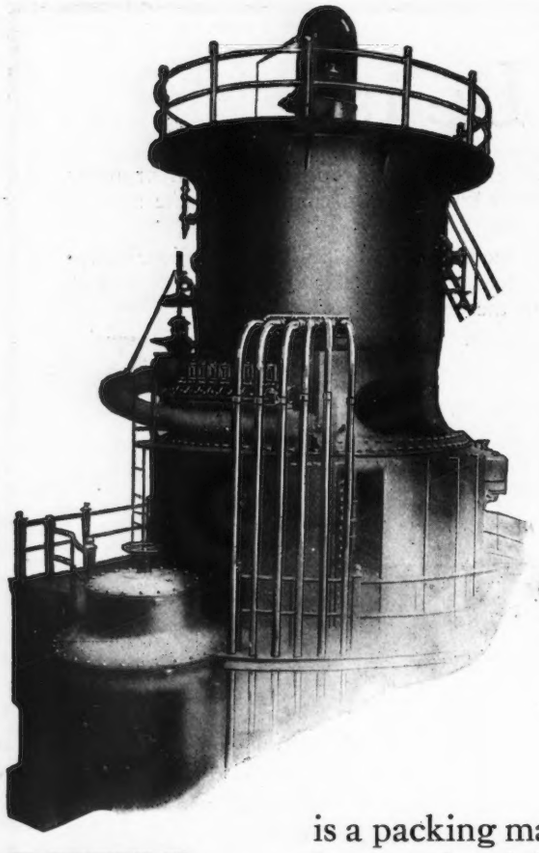



The No. 8 "Holtite" Belt Fastener illustrated above is intended for use on 8-ply belts. Standard sizes run from numbers 2 to 11 as shown mounted on the board in illustration at right. Ordinarily they are made of malleable iron with rust-proof finish; but can be supplied to order of drop-forged steel.




***Write for Details***

**The Conveying Weigher Co.**
**90 West Street, New York**



If you study the economy of power production you must not overlook the fact that the quality of the packing you use must advance with the rest of your development.

The packing found to be serviceable under ordinary steam pressures cannot possibly give economical service under high pressure superheated steam that you are now using.

TRADE MARK

# "PALMETTO"

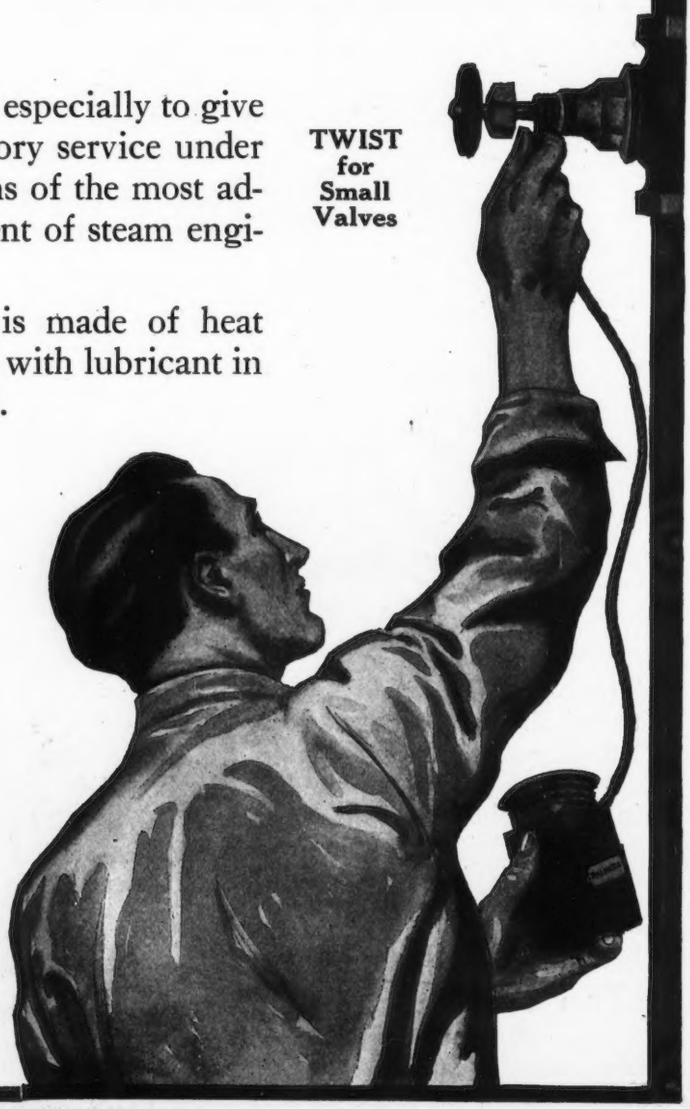
REG. U.S PAT. OFFICE

is a packing made especially to give long and satisfactory service under the hard conditions of the most advanced development of steam engineering.

"PALMETTO" is made of heat resisting materials with lubricant in each single strand.

**BRAIDED**
Round and Square for Rods

**TWIST for Small Valves**



**"PALMETTO" DOES NOT HARDEN IN SERVICE.**

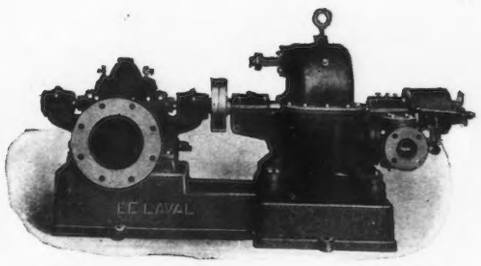
***It is made to give long service, and not frequent sales***

*If you will let us send you working samples and test them you will know for yourself that "PALMETTO" is the packing you should use. No charge for samples.*

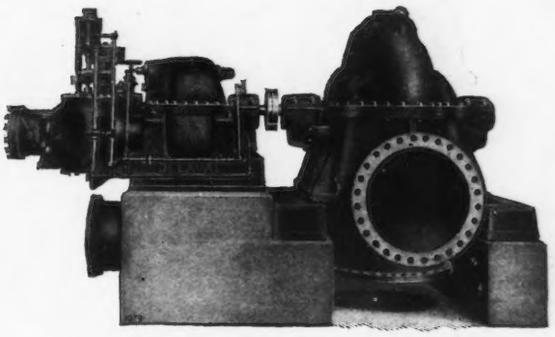
## Greene, Tweed & Co.

*Sole Manufacturers*

**109 Duane St., New York**




De Laval Single-Stage Pump, directly connected to De Laval Steam Turbine.



De Laval Single-Stage Gas Blower, driven by De Laval Multi-Stage Steam Turbine; 30,000 cu.ft. per minute against 2 lbs. per sq.in.

# NO VALVES, NO VIBRATION
## AND PRACTICALLY NO WEAR IN
# DE LAVAL CENTRIFUGAL PUMPS AND BLOWERS

In Centrifugal Pumps and Blowers there are no troublesome valves requiring frequent replacement. Parts subject to wear are reduced to a minimum and are easily replaced.

The flow and pressure are uniform and can easily be regulated automatically.

De Laval Centrifugal Pumps and Blowers have horizontally split casings, so that they are easily opened for inspection or cleaning without disturbing connecting piping. All parts subject to wear are made on a limit-gauge interchangeable basis, and new parts, as for example labyrinth packing rings of pumps, can be ordered by number and inserted by the user.

De Laval Steam Turbines are made for all steam conditions, condensing and non-condensing, or to operate upon the exhaust of reciprocating units.

All De Laval machines are guaranteed as to capacity and efficiency and are fully tested before leaving our shops.

***State requirements and conditions, and literature and full data will be sent***

**Ask for Bulletin 72**

**Ask for Bulletin 72**

# DE LAVAL STEAM TURBINE CO.
**390 Johnson Ave.**
**TRENTON, N. J.**

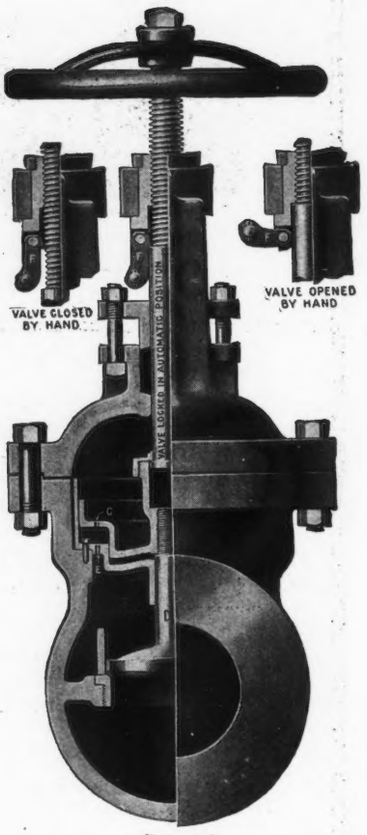
58

# Protect Your Power Station

Charles E. Golden, President and General Manager

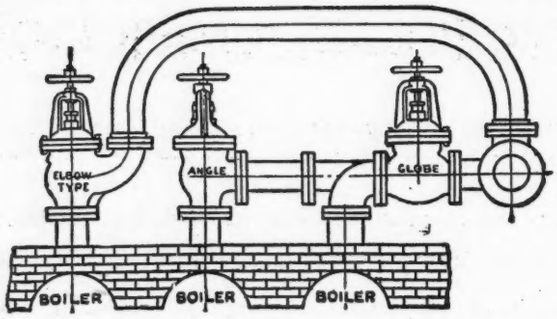
## *Mr. Golden Says:*

**"The non-return feature will protect your boilers in case of accident such as a burst tube. The triple-acting feature will shut off all steam the instant that a steam pipe bursts. The valves can be tested AT ANY TIME DURING OPERATION without interference with the working of the plant—an exclusive feature that is vital for safety."**




Patented

## Golden-Anderson Automatic Double-Cushioned Combination Non-Return Valves



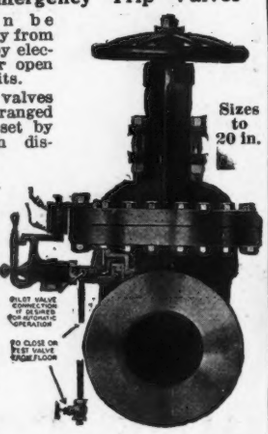

1. The only valves which can be tested while in service.
2. Can be instantly locked in automatic position.
3. Can be opened or closed the same as a regular gate or globe valve.
4. The Double Cushion feature permits rapid closure, and yet insures an easy, quiet and harmless seating.
5. Cutoff a boiler instantly when a tube breaks.
6. Live steam cannot enter a cold boiler.

**1650 Repeat Orders from U. S. Steel Corporation**

## Golden-Anderson

**Patent Double Cushioned Quick Closing Emergency Trip Valves**

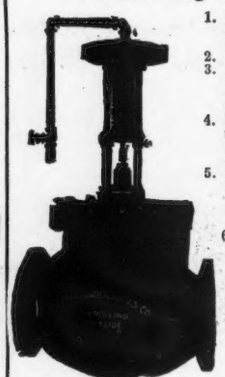
1. They can be tripped instantly from distant points by electricity on either open or closed circuits.
2. The only valves that can be arranged to open and reset by electricity from distant points.
3. Fitted with Corliss dash pot that insures perfect cushioning.
4. Operate without springs or tight fitting parts.
5. The H. C. Frick Co. have given 150 repeat orders.




## Golden-Anderson

**Patent Automatic Cushioned Controlling Altitude Valves**

1. Eliminate loss of water in reservoirs, stand-pipes, tanks, etc., by keeping the level constant.
2. Operate without floats or fixtures.
3. Uninterrupted service and a positive water supply assured without danger of water hammer surges or burst main.
4. No metal-to-metal seating. Positively cushioned by water and by air.
5. Can be made to close automatically during fire service.
6. Can be controlled by water or electricity from distant points.

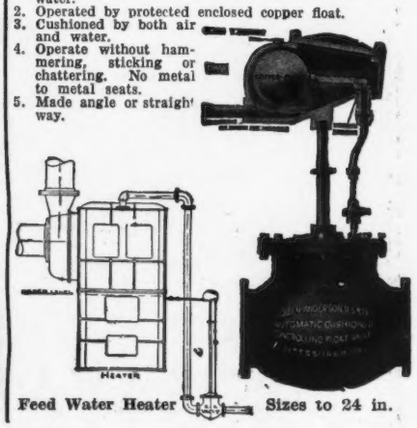


Sizes to 24 in.

## Golden-Anderson Pat.

**Automatic Cushioned Controlling Float Valve**

1. They carry a constant water level in feed water heaters by perfectly controlling the flow of make-up water.
2. Operated by protected enclosed copper float.
3. Cushioned by both air and water.
4. Operate without hammering, sticking or chattering. No metal to metal seats.
5. Made angle or straight way.



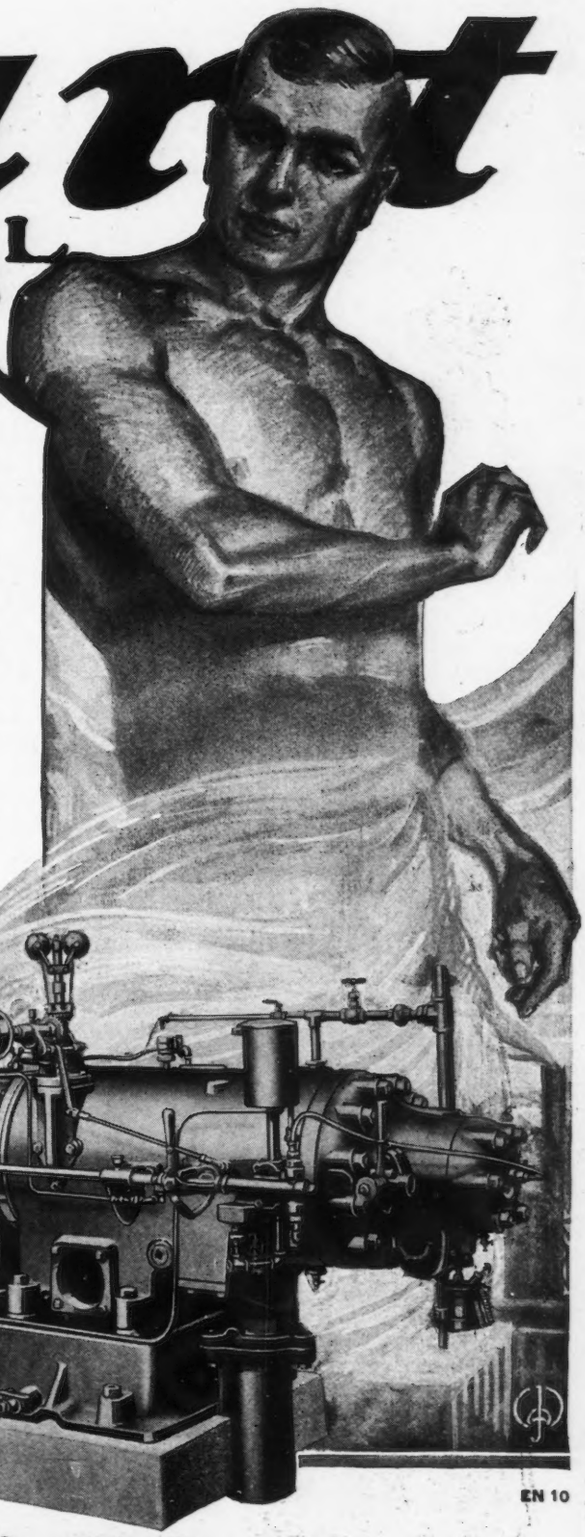

Feed Water Heater Sizes to 24 in.

***"Every Valve with an Absolute Guarantee."***

## GOLDEN-ANDERSON VALVE SPECIALTY COMPANY

**1217 Fulton Building, Pittsburgh, Pa.**

# Giant SEMI-DIESEL OIL ENGINES

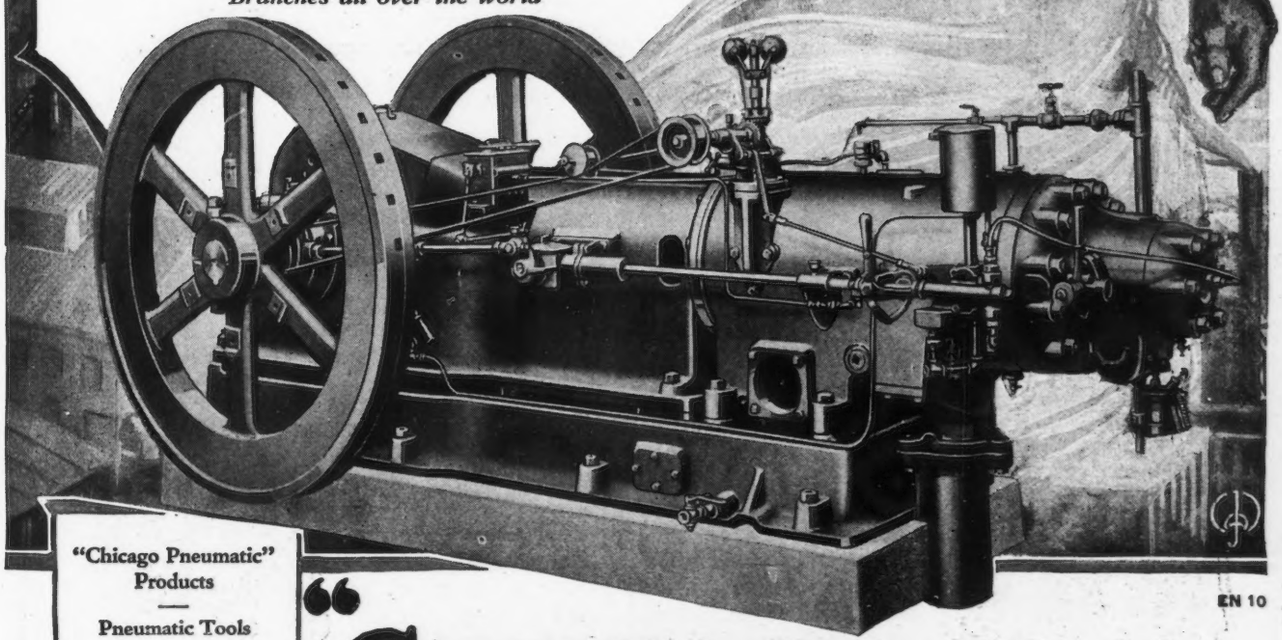


POWER costs of one-half cent per horse power hour are common amongst users of Giant Semi-Diesel Fuel Oil Engines. The economy and dependability of this prime mover for general purposes are proven facts.

Records are available showing the performance of Giant Engines under service conditions similar to yours. Put your individual power problem, without obligation on your part, before our experienced engineers. Your present power costs may be such that a Giant Engine will pay for itself within a short time—and then pay dividends on the investment.

Giant Oil Engines utilize the lower grades of cheap fuel oils, are built in capacities from 12 to 160 horse power, both single and duplex types. Ask for Bulletin 34-W.

**Chicago Pneumatic Tool Company**
1036 Fisher Building, Chicago, Illinois
*Branches all over the world*



EN 10

"Chicago Pneumatic" Products

Pneumatic Tools
Electric Drills
Air Compressors
Oil, Gas and Steam Engines
Vacuum Pumps
Rock Drills

# "CHICAGO PNEUMATIC"

*Depend upon that name*

# COCHRANE EQUIPMENT

## FOR STEAM PLANT EFFICIENCY

*For protecting engines and turbines* against water, use Cochrane Steam Separators. See our book on "Cochrane Separators, Their Design, Types and Uses."

*Receiver Separator*

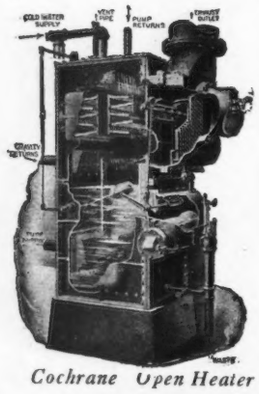
*For reducing vibration and pulsation in steam lines,* use Cochrane Receiver Separators, which have an ample well to receive large doses of water, and to supply steam storage.

*For purifying exhaust steam* of cylinder oil, use Cochrane Oil Separators.

*To utilize exhaust steam to heat the feed water* while providing a hot well and automatic raw water regulator, use the Cochrane Open Feed Water Heater. See our catalog on "Cochrane Heaters for the Profitable Utilization of Exhaust Steam."

*In connection with exhaust steam heating or drying systems* install the Cochrane Steam-Stack and Cut-Out Valve Heater and Receiver, which is fitted with a separator large enough to purify all of the exhaust steam in the plant, and with valves by means of which the body of the heater can be cut out of circuit for inspection or cleaning while the separator continues in operation. See our "Exhaust Steam Heating Encyclopedia."

*For measuring the evaporation per pound of coal,* install the Cochrane Metering Heater. It performs all the functions of the standard Cochrane Heater, and besides accurately meters the water. See our book "Finding and Stopping Waste in Modern Boiler Plants."

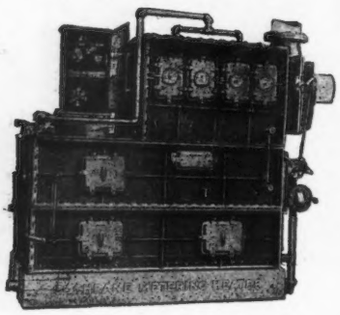


*Cochrane Open Heater*

*For protecting the exhaust steam system against excessive rise of pressure,* install the Cochrane Multiport Valve. This valve makes it possible to adjust the back pressure quickly and easily, but there is no possibility of overweighing, tying down or jamming, as by over-tightening of glands. See our book on "Multiport Valves, Their Types and Uses."

*For preventing vacuum backing up through the mixed flow turbine to the engine exhaust line* and thereby drawing in air to the detriment of the vacuum, use the Cochrane Multiport Flow Valve, explained in the "Multiport catalog."

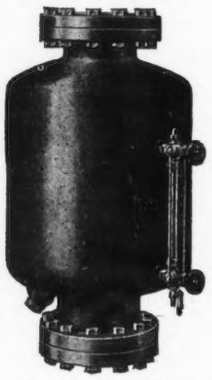
*For protecting the boilers against scale and corrosion* and keeping out sludge and sediment, while at the same time securing all the advantages of heating the water to the maximum temperature, install the Sorge-Cochrane Hot Process Water Softener. See "Hot Water for Steam Boilers."



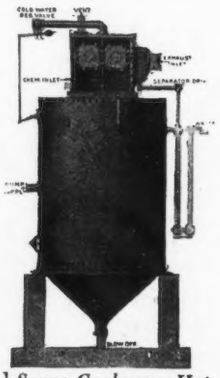
*Int. View Cochrane Metering Heater*

COCHRANE ENGINEERING SERVICE. Our organization offers its assistance in connection with the profitable utilization of exhaust steam for heating water for boiler feed and other purposes, and for heating buildings, drying materials, operation of low pressure turbines, also for the softening and metering of water. Even if you have no present problem, you may obtain valuable suggestions from the Cochrane literature above mentioned.

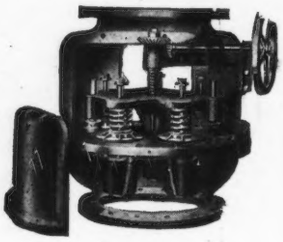
*Horizontal Separator*



*Vertical One-Piece Separator*



*Sorge-Cochrane Hot Process Softener*



*Cochrane Multiport Valve*

# HARRISON SAFETY BOILER WORKS

**3204 N. 17th Street, Philadelphia, Penna.**

**Manufacturers of the Celebrated Cochrane Lines, Including Open Feed Water Heaters, Steam-Stack and Cut-Out Valve Heaters and Receivers, Metering Heaters and Independent Meters. Sorge-Cochrane Hot-Process Water-Softeners, Steam and Oil Separators, and Multiport Back-Pressure, Atmospheric Relief, Flow and Check Valves.**

# The National Renewable Fuse

The National Renewable Fuse is the only fuse with the renewable feature that is APPROVED by the Associated Factory Mutual Fire Insurance Companies. Here is one renewable fuse which may be used without sacrificing the security a fuse must give to your plant.

The "tell-tale" indicator keeps the amperage rating always in plain view when installed—a single glance at the fuse tells you that the circuit is properly guarded.

The National Renewable Fuse cannot be improperly reloaded. It is constructed so that it is impossible to use more than one element in any holder, nor can it be bridged with a piece of copper wire on the outside.

The National Renewable Fuse provides the security features of the old-style "one-time" fuse in exactly the same way. The element is in a powder-packed cartridge which confines and smothers the fierce heat of the arc when the fuse blows. It is a complete fuse within a protective shell.

When a blowout occurs simply slip out the blown cartridge and insert a new one—the cartridge costs but a small fractional part of the complete fuse. National Renewable Fuses are simple, accurate and economical. Send coupon for complete information, prices, and name of our nearest jobber.

***Send Coupon Today***

**Federal Electric Company**

**Representing**

**Federal Sign System (Electric)**

**Lake and Desplaines Sts., CHICAGO**

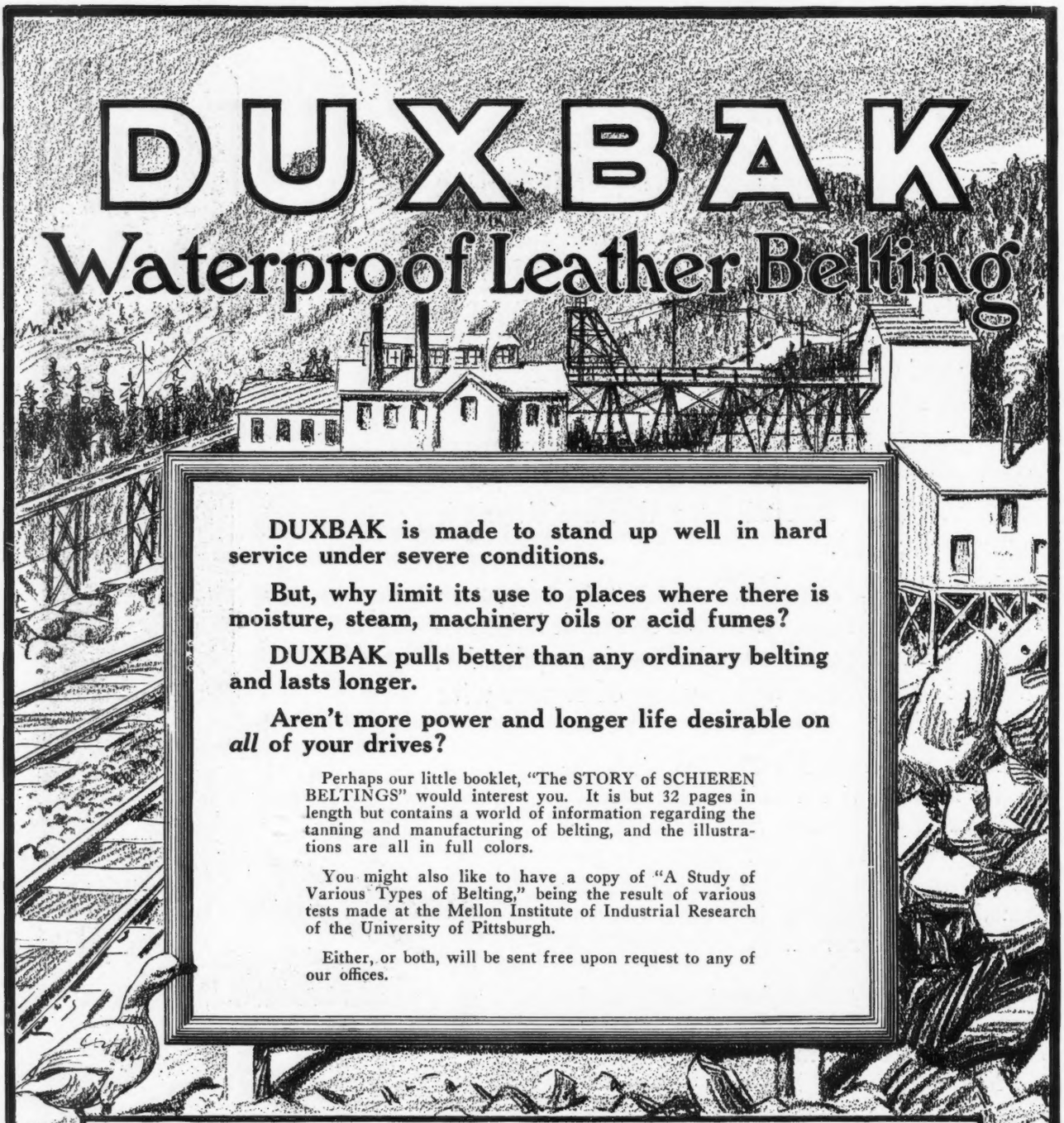
Federal Electric Company, representing Federal Sign System (Electric),
Lake and Desplaines Sts., Chicago.
Please send full information and prices of National Renewable Fuses and name of nearest Jobber.

Name.....

Address.....

Company.....

(E. M. J.-6)



# DUXBAK
## Waterproof Leather Belting

**DUXBAK is made to stand up well in hard service under severe conditions.**

**But, why limit its use to places where there is moisture, steam, machinery oils or acid fumes?**

**DUXBAK pulls better than any ordinary belting and lasts longer.**

**Aren't more power and longer life desirable on *all* of your drives?**

Perhaps our little booklet, "The STORY of SCHIEREN BELTINGS" would interest you. It is but 32 pages in length but contains a world of information regarding the tanning and manufacturing of belting, and the illustrations are all in full colors.

You might also like to have a copy of "A Study of Various Types of Belting," being the result of various tests made at the Mellon Institute of Industrial Research of the University of Pittsburgh.

Either, or both, will be sent free upon request to any of our offices.

**BRANCHES**

Atlanta, Ga..190 Marietta St.
Boston .....232 Summer St.
Chicago..128 West Kinzie St.
Cleveland..777 Rockwell Ave.
Dallas, Tex...The Texas Chas. A. Schieren Co., Inc., Murray & Williams Sts.
Denver....1752 Arapahoe St.
Detroit...72 Congress St., W.
Kansas City.1324 W. 12th St.

DUXBAK BELTING
TRADE MARK
Reg. U. S. Pat. Off.

Chas. A. Schieren Company
ESTABLISHED 1868

Tanners
Belt Manufacturers

*Main Office and Factory*
**39 Ferry St., New York, U. S. A.**
**Oak Leather Tanneries, Bristol, Tenn.**

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Memphis, Tenn., 477 So. Main St.
Milwaukee, Wis., 212 Sycamore St.
Philadelphia...226 N. 3rd St.
Pittsburgh.....337 2nd Ave.
St. Louis, 10th and No. Market Sts.
Salt Lake City...Dooly Bldg.
Seattle....305 First Ave., So.
San Francisco.257 Mission St.

# Rossendale-Reddaway

## FABRIC BELTS *for* EVERY SERVICE

THE ROSSENDALE-REDDAWAY B. & H. CO. NEWARK, N.J.
DURBAR SOLID WOVEN COTTON BELTING
THE ROSSENDALE-REDDAWAY B. & H. CO. NEWARK, N.J.
SENEGAL SPECIALTY CANVAS BELTING
ARABIAN HAIR BELT
REG. U.S. PAT. OFF.
THE ROSSENDALE-REDDAWAY B. & H. CO. NEWARK, N.J.
"CAMEL HAIR" "CAMEL" BRAND BELTING
REG. U.S. PAT. OFF.

## Motion is no proof of efficiency

Your messenger might start off on a dead run—but if he went a mile or two out of his way, you'd gain little by his speed.

A belt may keep the pulleys whirring, but if it slips or does not run true, you not only lose power—and, consequently, production—but your transmission gear suffers and the belt wears itself out too quickly.

Every drive must have the *right* belt—load and drive conditions considered. Anything short of *exactly* the right belt becomes an unnecessary loss. Loss—even though it may not be instantly visible. Unnecessary—because it *is* possible to buy the right belt from the Rossendale-Reddaway line of fabric belts for every service.

*Ask our engineering department for recommendations for your difficult drives. Their advice is competent and free.*

SINCE 1890
SOLE MAKERS OF
"CAMEL HAIR" "CAMEL" BRAND BELTING
REG. U. S. PAT. OFF.
IN THE U. S. A.

**The Rossendale-Reddaway Belting & Hose Co.**

**General Offices and Factory: Newark, New Jersey**

2004-R

# He knows valves—
# so he looks for the "Diamond Mark"

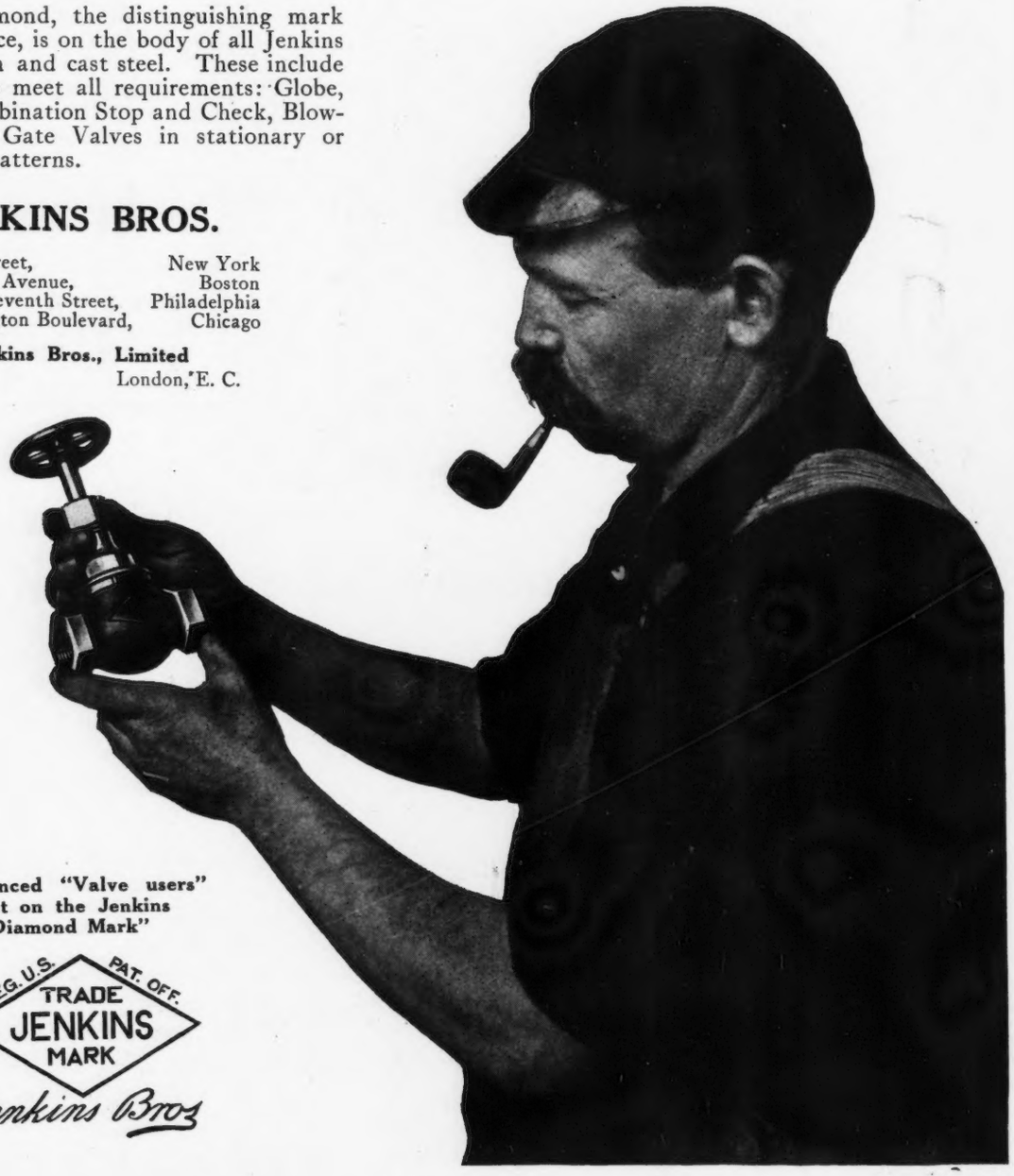
The man who sees and knows valve performance makes sure of Jenkins "Diamond Mark." He has seen genuine Jenkins Valves "on the job" year in and year out—he knows they are made to meet the test of service—and do.

The Jenkins Diamond, the distinguishing mark of unvarying service, is on the body of all Jenkins valves—brass, iron and cast steel. These include types and sizes to meet all requirements: Globe, Angle, Cross, Combination Stop and Check, Blow-off, Whistle and Gate Valves in stationary or traveling spindle patterns.

**JENKINS BROS.**

80 White Street, New York
524 Atlantic Avenue, Boston
133 North Seventh Street, Philadelphia
646 Washington Boulevard, Chicago

**Jenkins Bros., Limited**
Montreal London, E. C.



**Experienced "Valve users" insist on the Jenkins "Diamond Mark"**

REG. U.S. PAT. OFF. TRADE JENKINS MARK

*Jenkins Bros*

# Jenkins Valves

# FJAB

## Drill Steel

F J A B Hollow Drill Steel.

F J A B Solid Drill Steel.

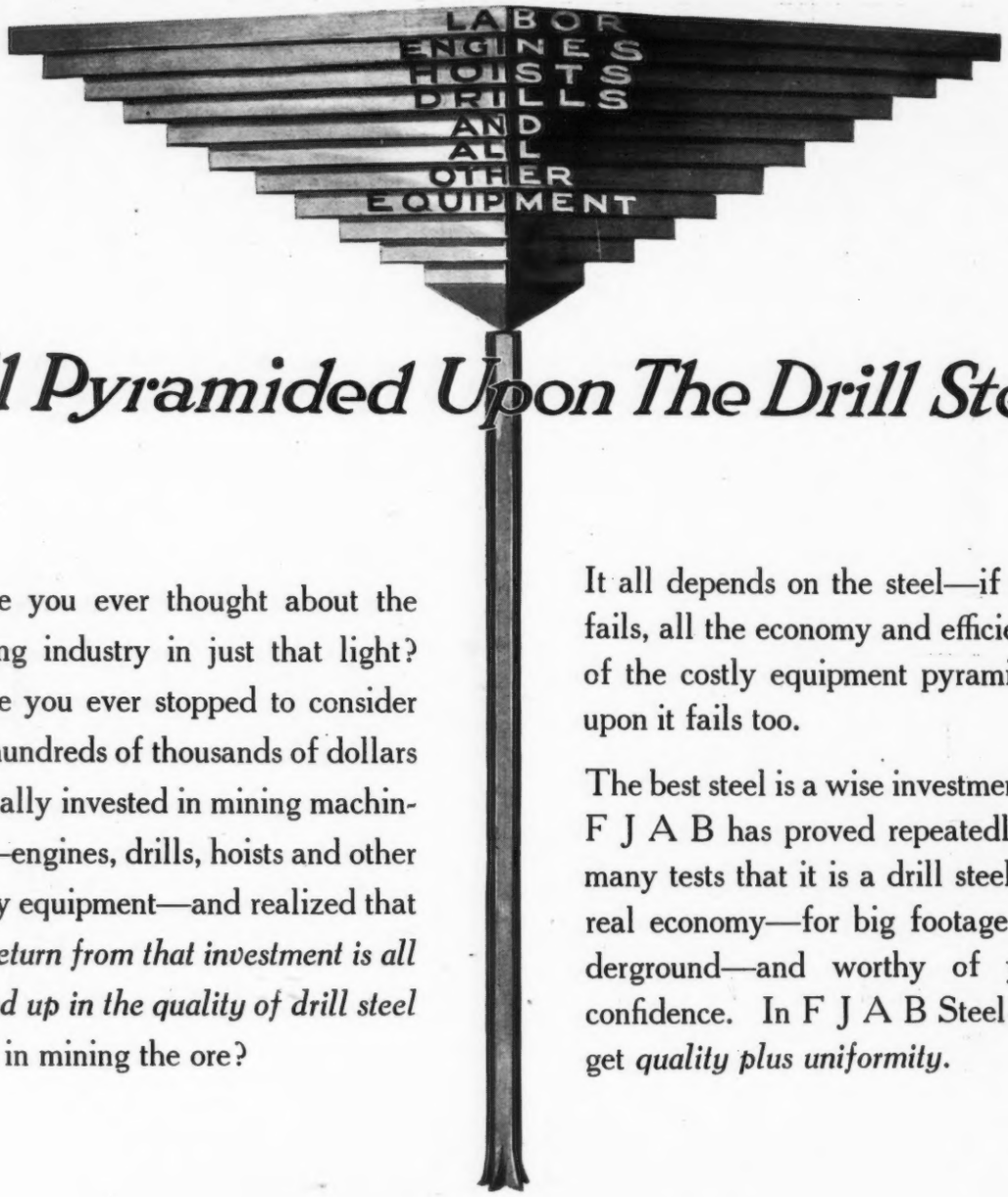
F J A B Rolled Auger Drill Steel, Heavy "L"
Much stronger than twisted steel.

Your orders for F J A B Steel—all the standard shapes and sizes, hollow or solid—in either large or small quantities will receive our best attention. You can depend on F J A B for quality and uniformity every time.

**A. MILNE & COMPANY,** 745 Washington St., New York
8 Oliver St., Boston, Mass.

(ESTABLISHED 1887)

Chicago Branch: 550 Washington Blvd., Chicago, Ill.
Sole and Direct Representatives for the United States and Canada




# *All Pyramided Upon The Drill Steel*

Have you ever thought about the mining industry in just that light? Have you ever stopped to consider the hundreds of thousands of dollars annually invested in mining machinery—engines, drills, hoists and other costly equipment—and realized that the *return from that investment is all bound up in the quality of drill steel* used in mining the ore?

It all depends on the steel—if that fails, all the economy and efficiency of the costly equipment pyramided upon it fails too.

The best steel is a wise investment—F J A B has proved repeatedly in many tests that it is a drill steel for real economy—for big footage underground—and worthy of your confidence. In F J A B Steel you get *quality plus uniformity.*

**HOLLOW ROCK DRILL STEEL**

# FJAB

**SOLID ROCK DRILL STEEL**

## A. MILNE & COMPANY

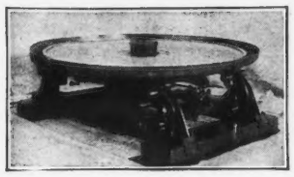
(ESTABLISHED 1887)

**745 Washington Street, New York**

**8 Oliver Street, Boston, Mass.**

**Chicago Branch: 550 Washington Blvd., Chicago, Ill.**

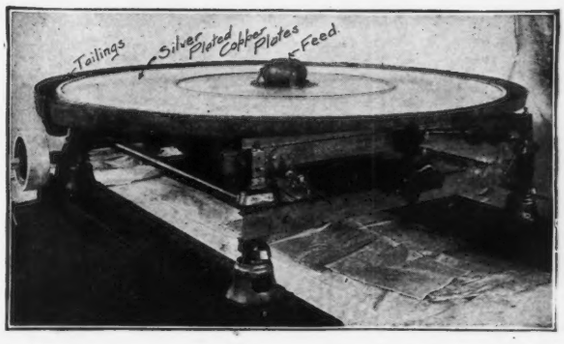
Sole and Direct Representatives for the United States and Canada.



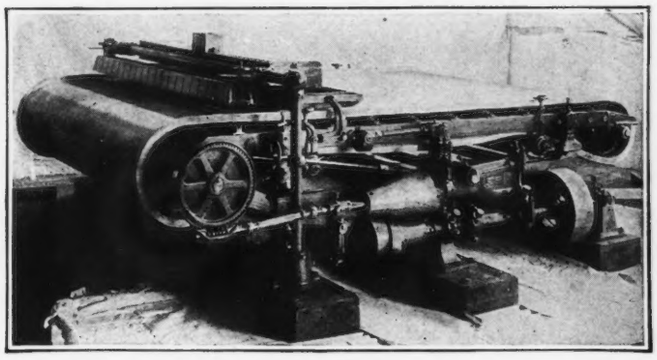
# Senn Amalgamators

**pan the gold into the quick, or onto the amalgamating plates**

They save the very coarse and the very fine gold, and the rusty gold.




Every inch in the surface of the amalgamating plates covering the deck moves 40 feet per minute. Every particle of pulp requires about 3 minutes to travel from the amalgam bowl to the tailings launder, across the amalgamating surface. The plates of one machine are therefore equivalent to 120 lineal feet of stationary plates, but they are more efficient than any amount of stationary plates, because the panning motion keeps the pulp loose and settles all the gold into the amalgam.



# Senn Concentrators

pan the finest as well as the coarse concentrates onto a moving belt that withdraws them from beneath the suspended gangue.

The continuous panning motion of the Senn keeps the barren gangue suspended and loose in a thick pulp. The thick, slow moving pulp avoids mashing away the very fine values.

**One Senn Concentrator Takes the Place of Four Ordinary Vanners**

**THE SENN WILL SAVE ALL THE PAN CAN SAVE**

## Senn Concentrator Company

**1215-J First National Bank Building, SAN FRANCISCO**

When thinking of

# MILLING EQUIPMENT

—it will pay you to get our quotations and suggestions

We also invite your inquires for:

**Mining Machinery**

GOLD DREDGES

HYDRAULIC DREDGES

WATER TUBE BOILERS

CRUDE OIL BURNERS

BALL MILLS

FORGED STEEL BALLS FOR BALL MILLS

BUCKET PINS AND

SCREEN PLATES FOR GOLD DREDGES

*Our Engineers will gladly advise with you*

**Bethlehem Shipbuilding Corporation, Ltd.**

(UNION PLANT)

FORMERLY UNION IRON WORKS COMPANY

Plant: 20th and Illinois Streets Sales Office: 260 California Street

SAN FRANCISCO

# SECONDARY CRUSHERS

**IN SOME OF THE LARGEST PLANTS IN THE WORLD GYRATORIES AND COARSE ROLLS (used as secondary crushers) ARE BEING REPLACED BY**

# SYMONS VERTICAL DISC CRUSHERS

**Large Modern Plants Are Installing**

## SYMONS VERTICAL DISC CRUSHERS

**Following Primary Breakers**

## BECAUSE

1st. They take the same size of feed.

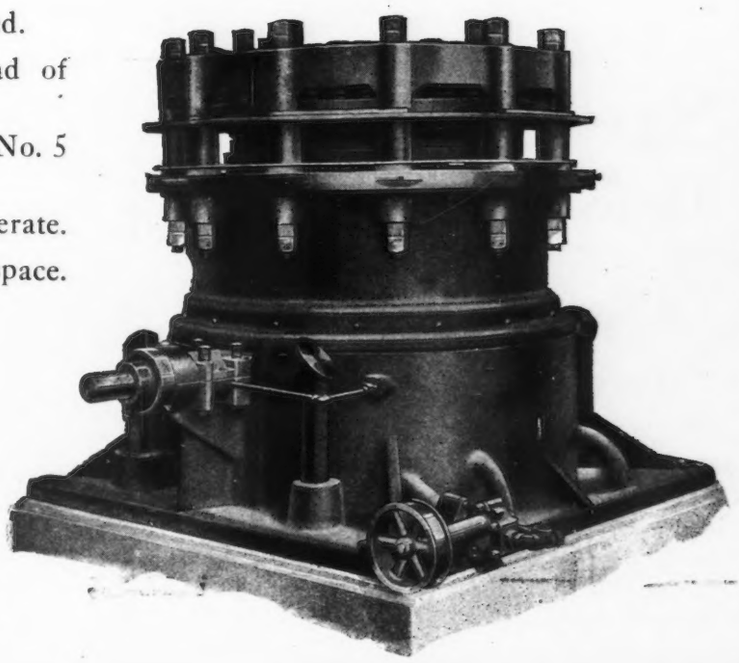
2nd. They crush to ½ in. instead of 1½ in.

3rd. One Disc Crusher equals two No. 5 Gyratories.

4th. They require less power to operate.

5th. They require minimum floor space.

*Write for further details*



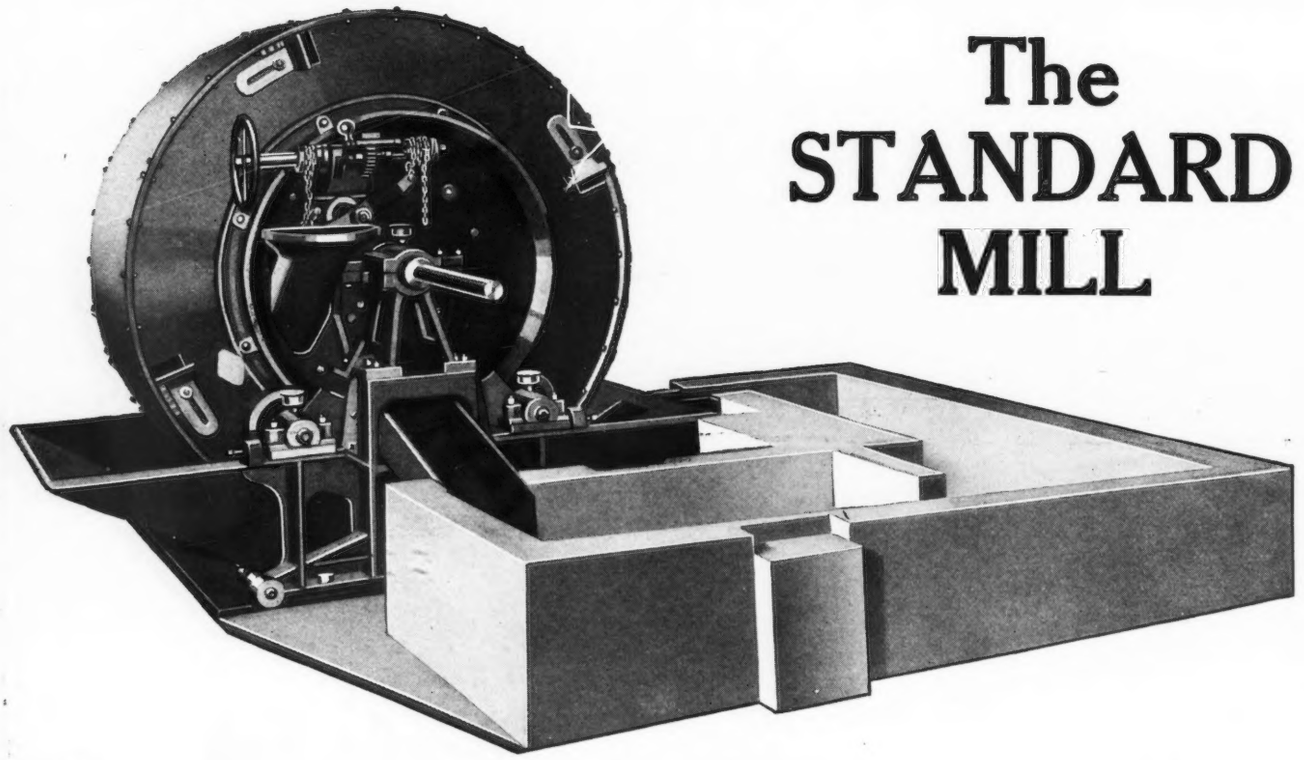
***Manufactured and sold by***

**Chalmers & Williams**

**Arnold St., Chicago Heights, Ill.**

**We also manufacture Jaw Crushers, Gyratory Crushers, Stamp Mills, Nissen Stamps, Crushing Rolls, Huntington Mills, Chilean Mills, Ball Mills, Revolving Screens, Pulsating Screen and Burt Filters.**

# SIMPLICITY



## The STANDARD MILL

## Saves

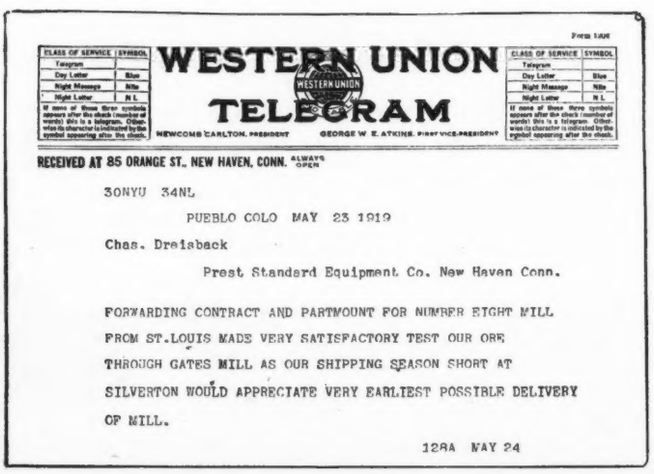
**Time** Ore from primary crusher reduced to tailing for secondary tables or flotation in one operation.

**Labor** For operating ball mills, conveyors, classifiers, jigs, tables, etc.

**Power** The No. 8 "Standard Mill" will crush and pulverize 200 to 400 tons of ore in 24 hours with a 15-hp. motor.

**Repairs** All crushing and grinding of ore is done with two manganese steel rolls. Why pay good money for steel balls and pebbles to grind when you can use a mill that grinds the ore. The crushing rolls revolve on large well lubricated bearings.

## Proof of Our Claims



WESTERN UNION TELEGRAM

NEWCOMB CARLTON, PRESIDENT GEORGE W. E. ATKINS, FIRST VICE-PRESIDENT

RECEIVED AT 85 ORANGE ST., NEW HAVEN, CONN. ALWAYS OPEN

30NYU 34NL

PUEBLO COLO MAY 23 1919

Chas. Dreisback

Prest Standard Equipment Co. New Haven Conn.

FORWARDING CONTRACT AND PARTMOUNT FOR NUMBER EIGHT MILL FROM ST.LOUIS MADE VERY SATISFACTORY TEST OUR ORE THROUGH GATES MILL AS OUR SHIPPING SEASON SHORT AT SILVERTON WOULD APPRECIATE VERY EARLIEST POSSIBLE DELIVERY OF MILL.

128A MAY 24

# ECONOMY

The new and novel in milling practice, whether it's a machine or process, is always regarded with a very natural hesitancy by engineers and mill operators—and we have had this to overcome in introducing the STANDARD MILL.

Here's a machine that simplifies milling operations—that eliminates ball mills, conveyors, classifiers, jigs and tables in the treatment of many ores—that has big possibilities on your ore—can you afford to delay serious consideration?

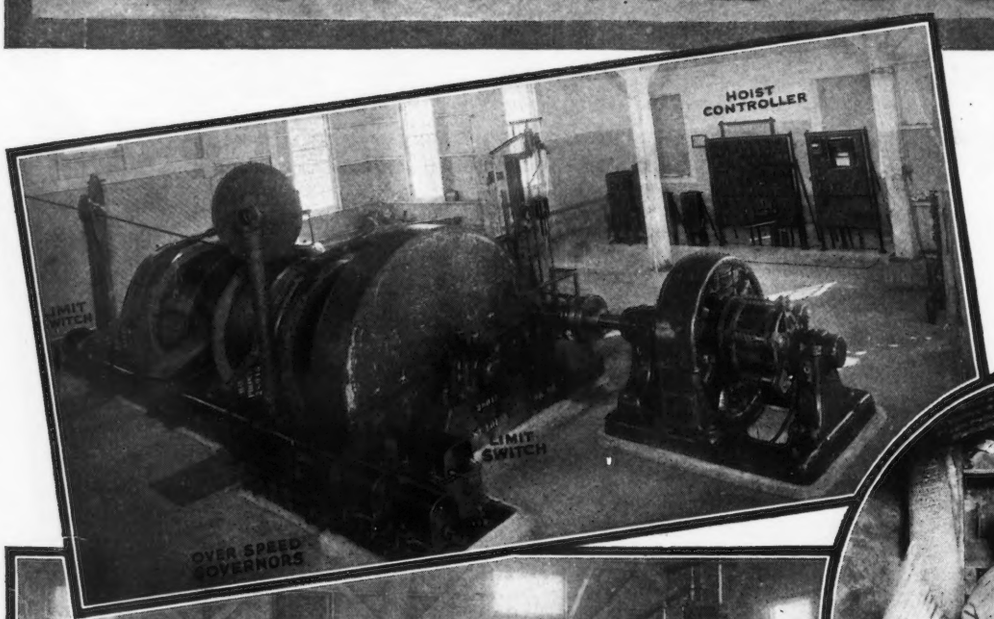
THE STANDARD MILL is a machine for crushing, grinding, pulverizing and *concentrating* in one operation—one pass of the mill—it produces a smelting concentrate direct from primary breaker feed—it reduces the bulk of ore passing thru your plant—and gives a tailings product ideal for secondary tables and flotation.

Why not investigate? The "STANDARD Flow Sheet" has many advocates—send today for complete information or let us arrange for tests on your ore.

**STANDARD EQUIPMENT CO.**
**New Haven, Conn., U. S. A.**

# The STANDARD MILL

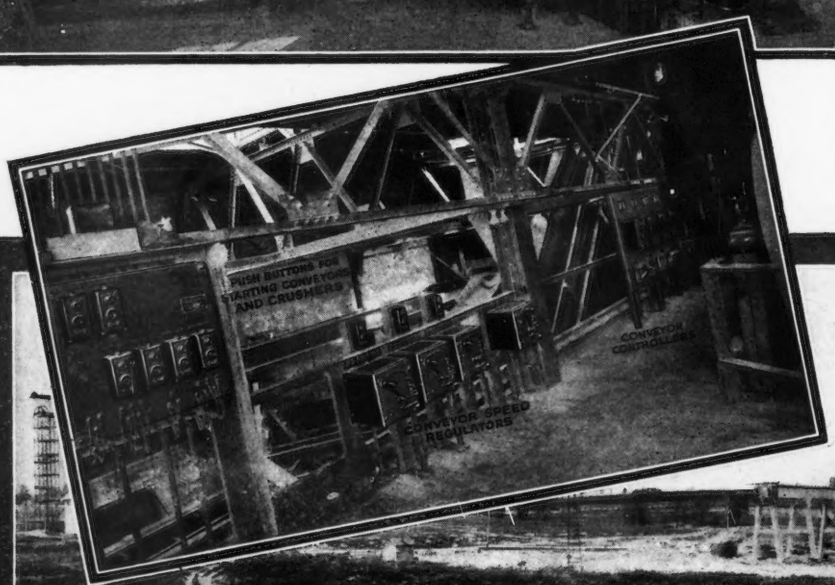
# C-H MINE DUTY

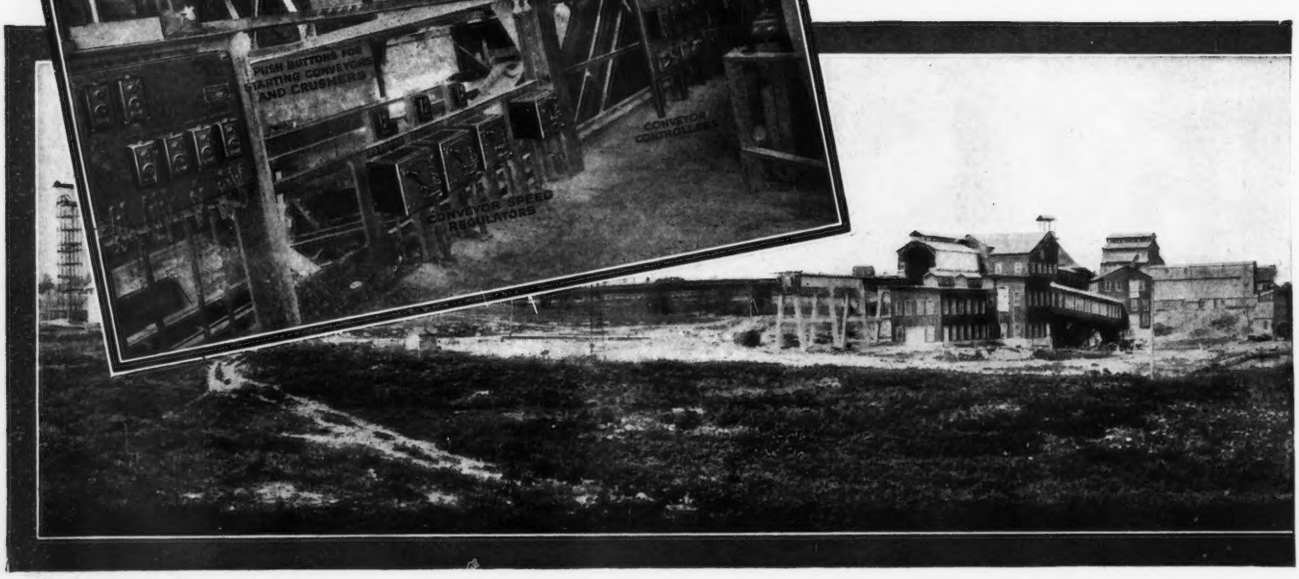



Hoist Room, St. Louis Smelting and Refining Co. Some of the C-H Equipment is indicated.

Operator in mine with Master Controller controlling hoist.

C-H



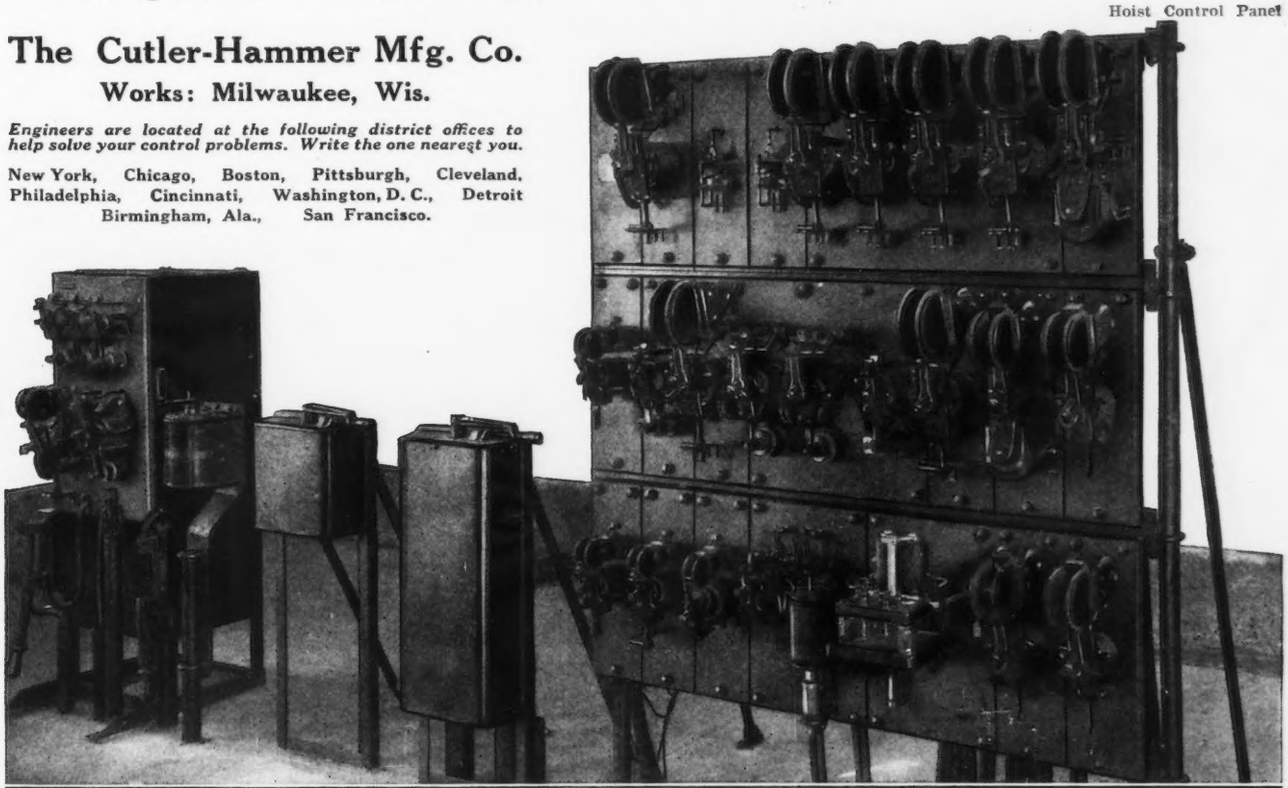



# CONTROLLERS

## C-H Control from Main Entry to "Chat" Dump

At The St. Louis Smelting and Refining Co., St. Francois, Mo., complete control is secured through the use of Cutler-Hammer Starting, Regulating and Braking Equipment. Part of this equipment, which can be seen in the illustrations, includes a Magnetic Mine Hoist Control Panel, two Straight Line Drive Drum Masters, two Traveling Cam Limit Switches, two Overspeed Governors, a Transfer Switch, a Motor-Operated Brake and a Lifting Solenoid. Some of the rest are a pump controller and numerous conveyor controllers operated from push button stations. The complete equipment from main entry to "chat" dump is interestingly described in Publication 418.

Hoist Control Panel

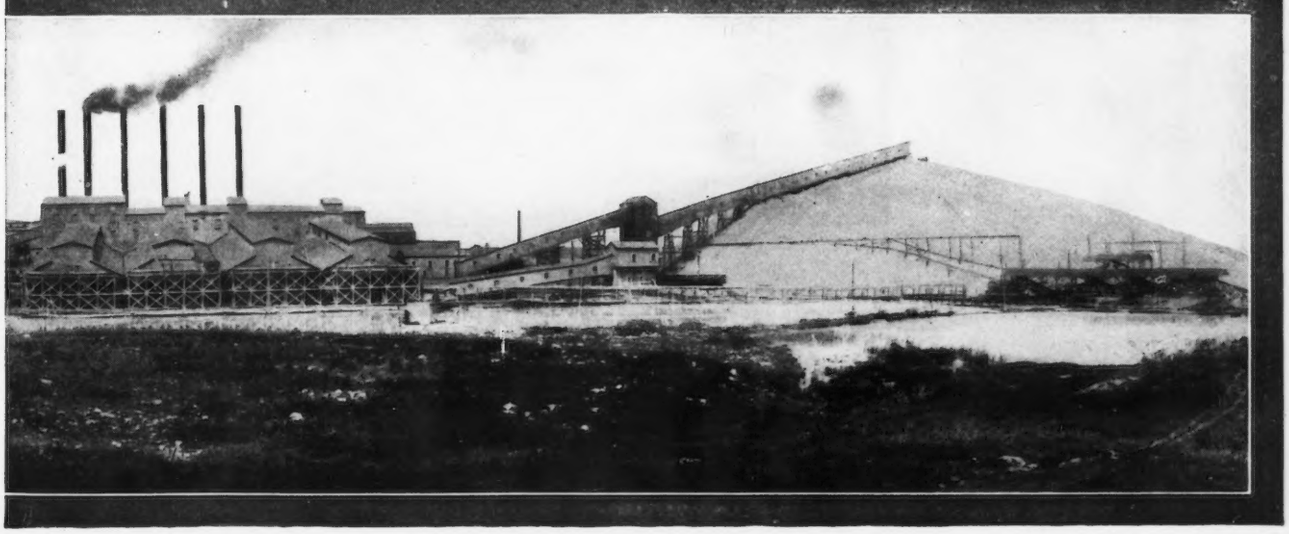


**The Cutler-Hammer Mfg. Co.**

**Works: Milwaukee, Wis.**

***Engineers are located at the following district offices to help solve your control problems. Write the one nearest you.***

**New York, Chicago, Boston, Pittsburgh, Cleveland, Philadelphia, Cincinnati, Washington, D. C., Detroit Birmingham, Ala., San Francisco.**



*Coarse Crushing Plant and Concentrator Mill Building. Alaska Gastineau Gold Mining Co., Thane, Alaska.*

## We Go Anywhere

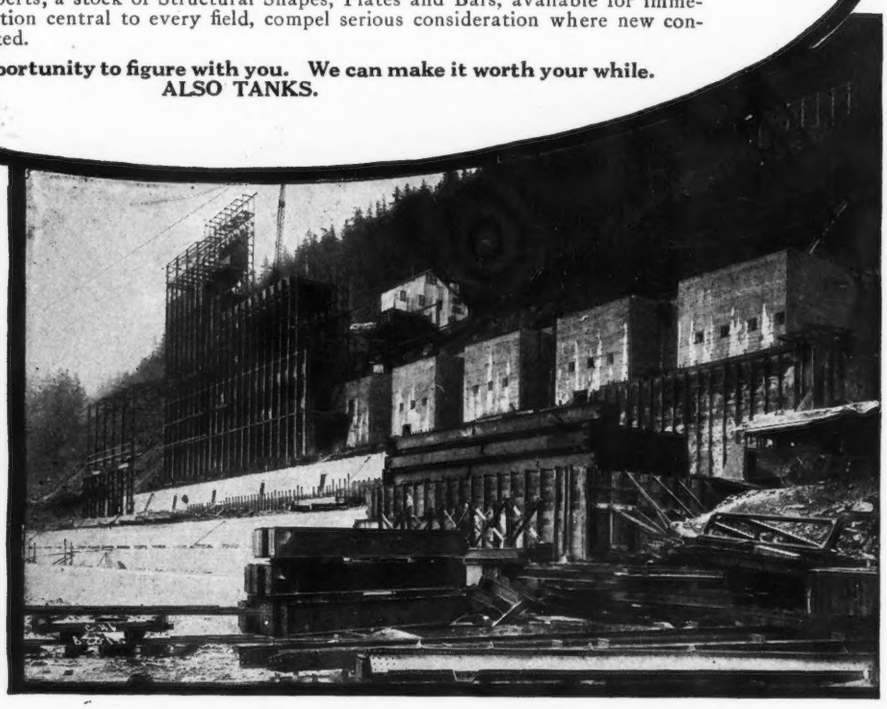
From the sun-blistered mountains of Arizona to the frozen hills of Alaska—wherever metal is mined and worked—will be found evidence of our skill in the construction of plants for

## Mines, Mills and Smelters

***Nearly 50% of the existing plants today were fabricated and erected by us.***

Skilled erection crews, supervised by practical Construction Engineers; modern fabricating shops, in charge of experts; a stock of Structural Shapes, Plates and Bars, available for immediate work, and a location central to every field, compel serious consideration where new construction is contemplated.

**We solicit the opportunity to figure with you. We can make it worth your while.**
**ALSO TANKS.**

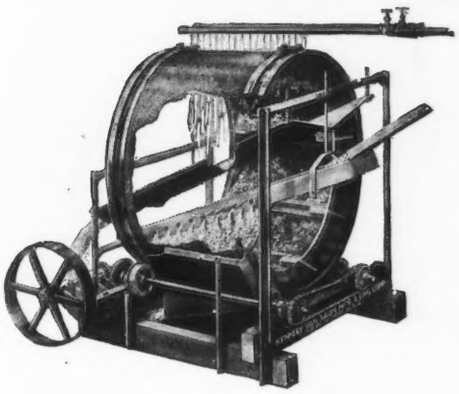


*Same plant in course of Construction.*

## Fabricated and Erected By

# Kansas City Structural Steel Company

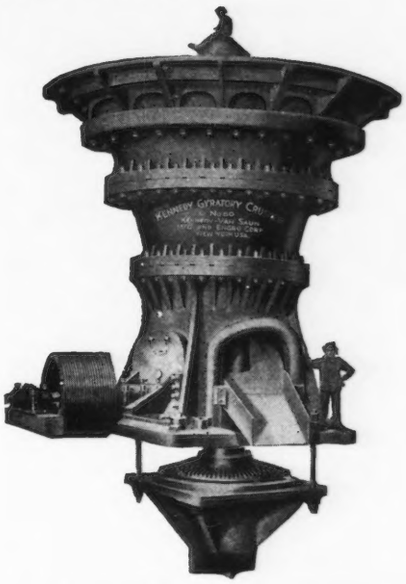
## Kansas City, U. S. A.



# KENNEDY-VAN SAUN PRODUCTS

## CRUSHING, GRINDING, PULVERIZING MACHINERY

**Milling**
**Quarrying**
**Cement Mill**
**Equipment**



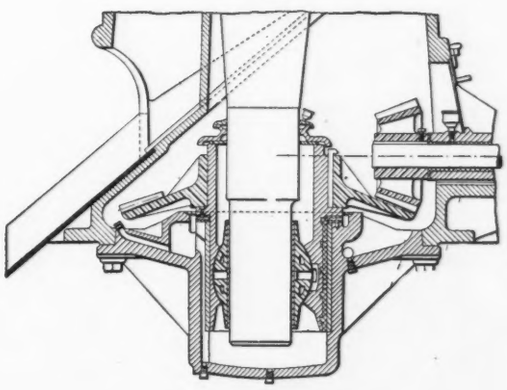
## MAXIMUM TONNAGE AT LOWER COST

### *The Maxton Screen*

One of the latest KVS Products—an *efficient* and *economical* tubular screen-classifier for sizing fine wet pulps, between the limits of 10 and 100 mesh.

The MAXTON SCREEN *realizes an ideal,* it makes practicable every theoretical advantage of screen sizing—simplicity—low cost—low repairs and labor—and high capacity.

Here is just one Maxton feature—the life of wire screening in the Maxton Screen ranges from 150% to 250% greater than that of any other screen sizing machine under the same conditions. There's a reason for this, and the other advantages. Write for Bulletin No. 4



### The Kennedy Gyratory

highly recommended by mill operators for heavy duty crushing, and

### The Gearless Crusher

a gyratory with direct rope-sheave or pulley drive permitting double the eccentric speed—therefore double the capacity, for crushing direct to ½-in. size or less; are both equipped with

### *Our Ball and Socket Eccentric*

an exclusive self-aligning feature that *eliminates* a serious trouble common to other gyratories—overheating and frequent rebabbiting. There are other remarkable features—write for our illustrated bulletins.

**Kennedy-Van Saun Mfg. & Eng. Corporation**

**120 Broadway, New York City**

SPECIFY KVS PRODUCTS

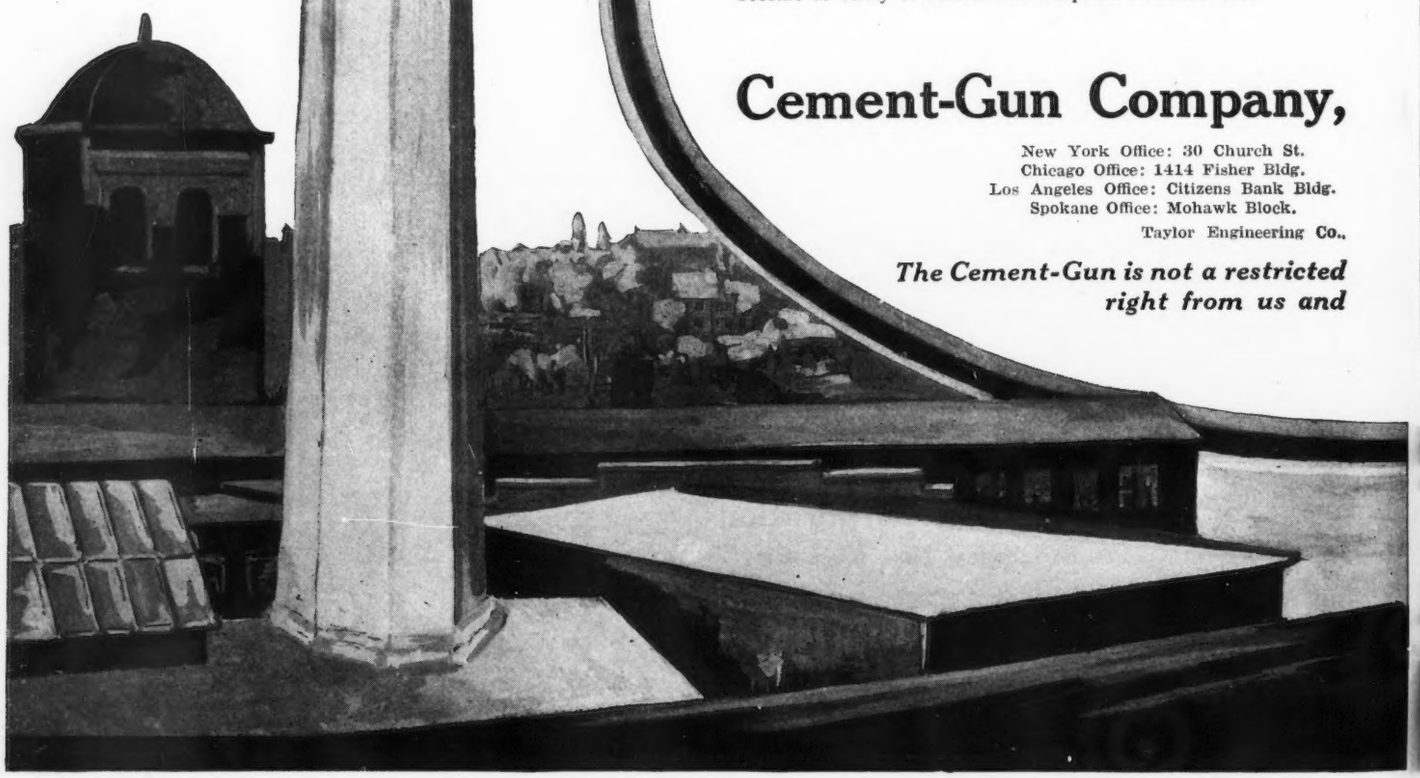
# CEMENT-GUN Saves

## How Protective Coatings

HERE are shown two cases where the timely use of the Cement-Gun saved a great deal of money, and made it unnecessary to build new stacks. The brick stack at the left is at the Brookside Mills, Knoxville, Tenn. It was split open and practically ready to fall, when Messrs. J. M. Dunn & Son applied ¾ in. tie rods every four feet around the stack, tightened them and closed the largest cracks, then sheathed the whole structure with No. 10 square mesh wire and shot on a 2½ inch coating of Gunite.

The Gunite (the cement-sand product of the Cement-Gun) penetrated every crack, thoroughly sealed up each fissure, and with the heavy reinforcing, has practically made a complete new wall around the stack from bottom to top.

At the right are shown two of five steel stacks at the Pittsburgh Crucible Steel Company's plant, which had become so badly corroded from sulphurous fumes that



## Cement-Gun Company,

New York Office: 30 Church St.
Chicago Office: 1414 Fisher Bldg.
Los Angeles Office: Citizens Bank Bldg.
Spokane Office: Mohawk Block.
Taylor Engineering Co.,

***The Cement-Gun is not a restricted right from us and***

# Brick and Steel Stacks

## of Gunite Were Shot On

a man could stick his clenched fist through the steel at a hundred points.

Instead of building new stacks, they called in the Baker-Dunbar-Allen Company to Gunite the old stacks. First, heavy mesh wire was rapped around the stacks and firmly fastened. Then, starting at the bottom, the Cement-Gun operator shot on a good thick coating over the wire, and built up a series of five reinforced concrete stacks over the old, worn steel work.

As a matter of fact, today there is little left of the original steel stacks, for the sulphurous fumes have completed their deadly work. But the concrete is there to stay.

If you don't realize the extraordinary large field of action of a Cement-Gun around mines and smelters, in protecting masonry, in checking fire, rot and rust and in making buildings habitable; write for bulletins now.

## Inc., Allentown, Penna.

R. E. Cleaton & Co., 20 St. Nicholas St.
Montreal, Canada.
General Supply Co. of Canada, Ltd.,
Winnipeg, Canada
Vancouver, B. C.

***article. It may be purchased out-used by anyone.***

# AN ANNOUNCEMENT OF INTEREST

# TO ALL CONVEYOR USERS

One of the largest conveyor manufacturing companies in the world is now placing Hyatt Roller Bearing equipped conveyors on the market.

The engineers of this conveyor company carried out thorough service tests that convinced them of the durability, power saving and positive oiling advantages of Hyatt Roller Bearings.

They found that because of the power reduction they were able to use *one* long Hyatt equipped conveyor to do the work that required *three* shorter plain bearing conveyors.

A complete account of what was accomplished on this conveyor together with the name of this progressive conveyor manufacturing company, will appear in the July 26th issue of the Engineering and Mining Journal.

1014

Motor Bearings Division
Detroit, Mich.

**HYATT ROLLER BEARING COMPANY**
**INDUSTRIAL BEARINGS DIVISION**
**METROPOLITAN TOWER, NEW YORK**

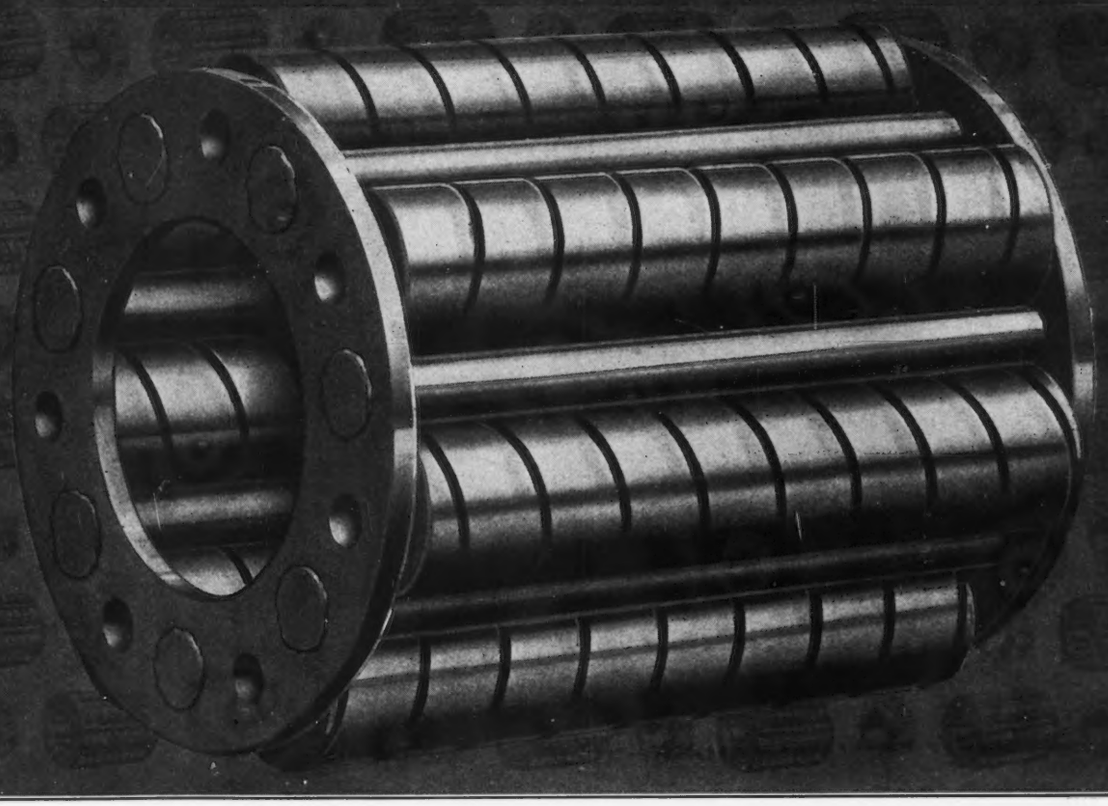
*Manufacturers of bearings for mine cars, ore cars, steel mill cars, roller tables, trolleys, cranes, hoists, machine tools, line shafts, countershafts, concrete machinery, textile machinery, conveyors, lift trucks, industrial trucks, railway service cars, storage battery locomotives, etc.*

Tractor Bearings Division
Chicago, Ill.

# HYATT BEARINGS FOR CONVEYORS

# Do You Realize—

—that for economical ore car operation the durability and positive oiling action of Hyatt Roller Bearings are just as important as their easy running qualities?



**"A Special Cloth for Every Filtration Purpose"**

We have developed a special filter cloth for every filtration purpose for instance: for

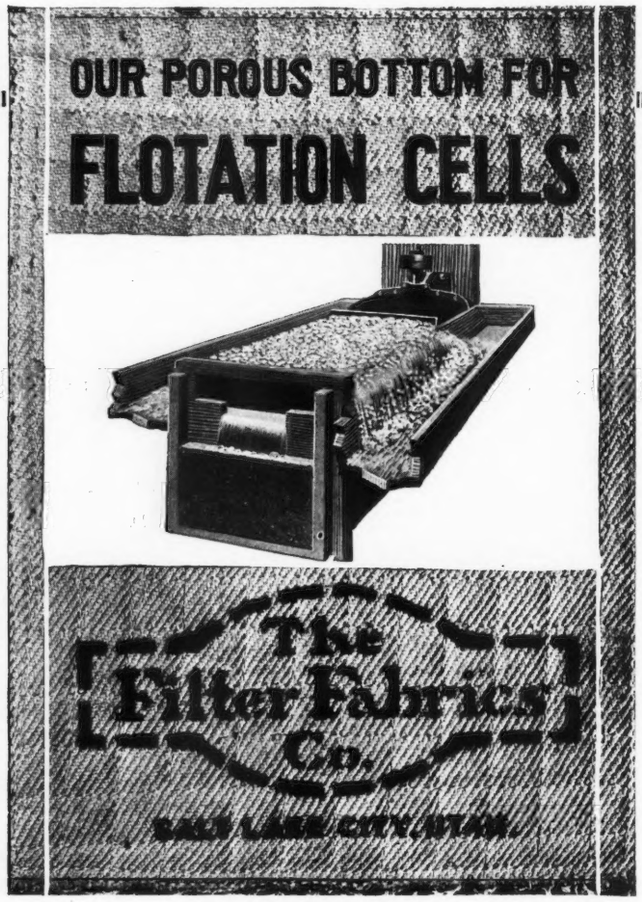
**Dewatering Flotation Concentrates**

**Washing and Filtering Cyanide Slimes**

**Chemical Filtration Fume and Dust Bags.**

We would be pleased to suggest the best kind of cloth for your filtration problem.

***Write for our book of samples***




The results obtained by the use of our Cell Bottoms have never been excelled.

Many substitutes have been tried out, but our Fabric quilted by our method remains pre-eminent.

**Filter Bags**
**Filter Covers**
**for Every type of Filter**

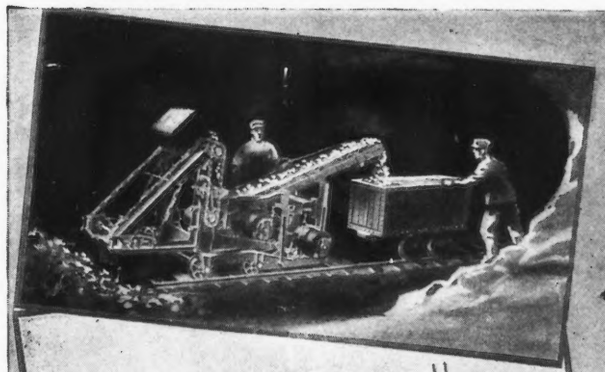
**Bags and covers made to fit Kelly Filters, American Filters, Oliver Filters, Portland Filters, etc.**

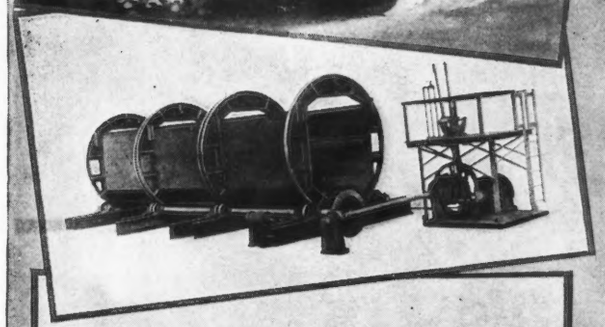
**Ducks, Cordage Twines, Burlap and Ore Sacks, etc.**

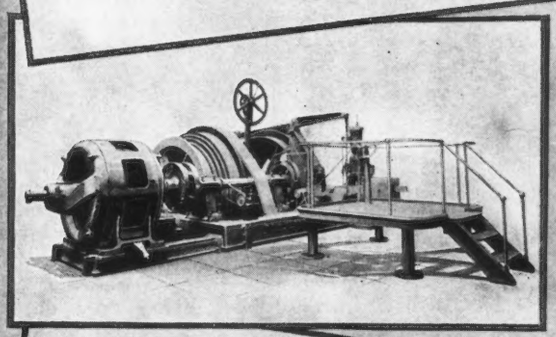
***We can make immediate shipment from stock, Salt Lake City, of ordinary orders and are backed by fifteen cotton mills to exexcute large ones.***

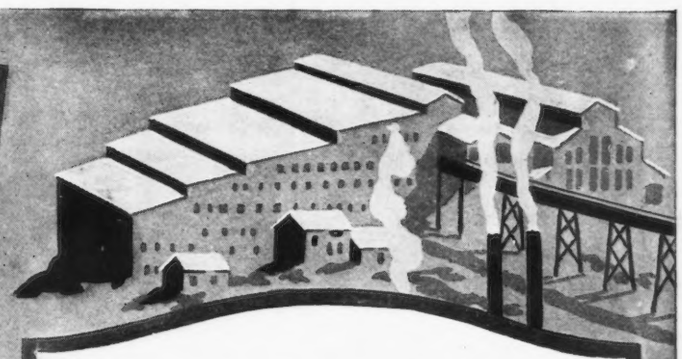
# The Filter Fabrics Co.

**Felt Building, Salt Lake City, Utah**









# ORE-HANDLING EQUIPMENT

## From Mine to Furnace

In the panels at the left are illustrated five W-S-M specialties for handling ore between the working faces underground and the furnaces in which it is smelted.

Underground Loading Machines, Rotary Car Dumps, Electric Hoists, Ore Handling Cranes, and Moveable Car Dumpers are all important examples of W-S-M engineering skill; but they are not by any means our entire line.

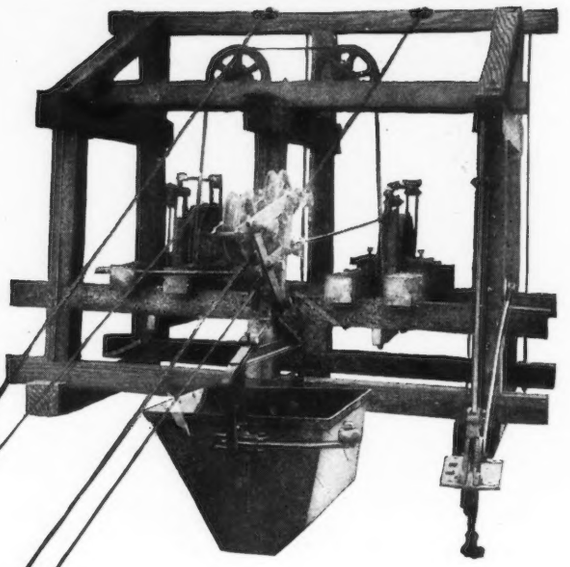
Whatever your ore-handling problem may be it is well worth while to consult our engineers.

*Write for illustrated bulletins of our standardized equipment.*

**The Wellman-Seaver-Morgan Co.**
**Cleveland, Ohio**

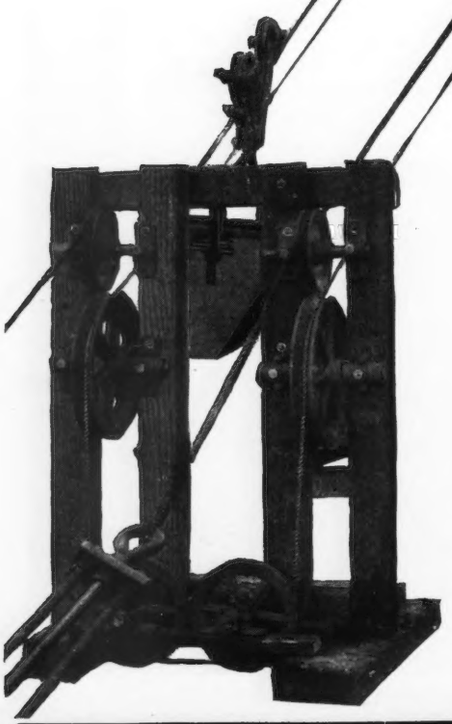
Plant of Wellman-Seaver-Morgan Company at Cleveland, Ohio

# The Perfect Tramway



That's what mining operators say about the Fulton Engine Works' double acting aerial wire rope tramway.

It is worth *your* thorough investigation.



The illustration shows typical upper and lower stations of tramways recently built by us for Anchor Mines, Arentz & Perkins, Arizona-McGinnas Copper Co., DePuy Company, Goodsprings Anchor Co., C. A. Weaver & Co., Yount & Fayle.

The Fulton Engine Works' tramway is simple in action, dumps automatically, has practically nothing to get out of order, inexpensive to operate. Extra parts can be quickly obtained without long waits.

The Fulton Gravity Plane (three-rail and double track system) for use on hillsides is built along similar lines.

*Tell us your problems and let our engineers assist you.*

***We also make***

**Standard and Special Mining Hoists**
**Derricks Cranes Elevators**
**Mine and Mill Equipment**

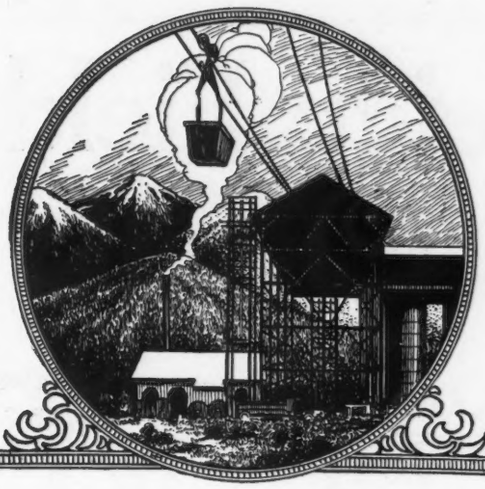
## The Fulton Engine Works

**Incorporated**

**Los Angeles, California**

Founders
Engineers
Machinists
Boiler Makers

San Francisco Office
510 Call Building



THE economical transportation of materials by means of Leschen Aerial Wire Rope Tramways is not a matter of conjecture or theory, but a fact established by the actual operation of numerous installations.

They operate successfully over any kind of country. They cross hills and rivers without expensive grading or bridge work. They are not affected by weather conditions.

They are economical to operate both as to power and labor; oftentimes they can be run by gravity.

The details, quality, workmanship, design and manufacture of all Leschen Tramways are the outcome of many years of practical experience in this class of work.

We manufacture Aerial Tramways in various systems, and are therefore able to furnish that type of Tramway best suited to any existing condition.

Your correspondence on this subject is solicited.

*Established 1857*

**A. Leschen & Sons Rope Co.**

**St. Louis, U. S. A.**

New York
Chicago

Denver
San Francisco

*"Hercules"*
*(Red-Strand)*
*Wire Rope*

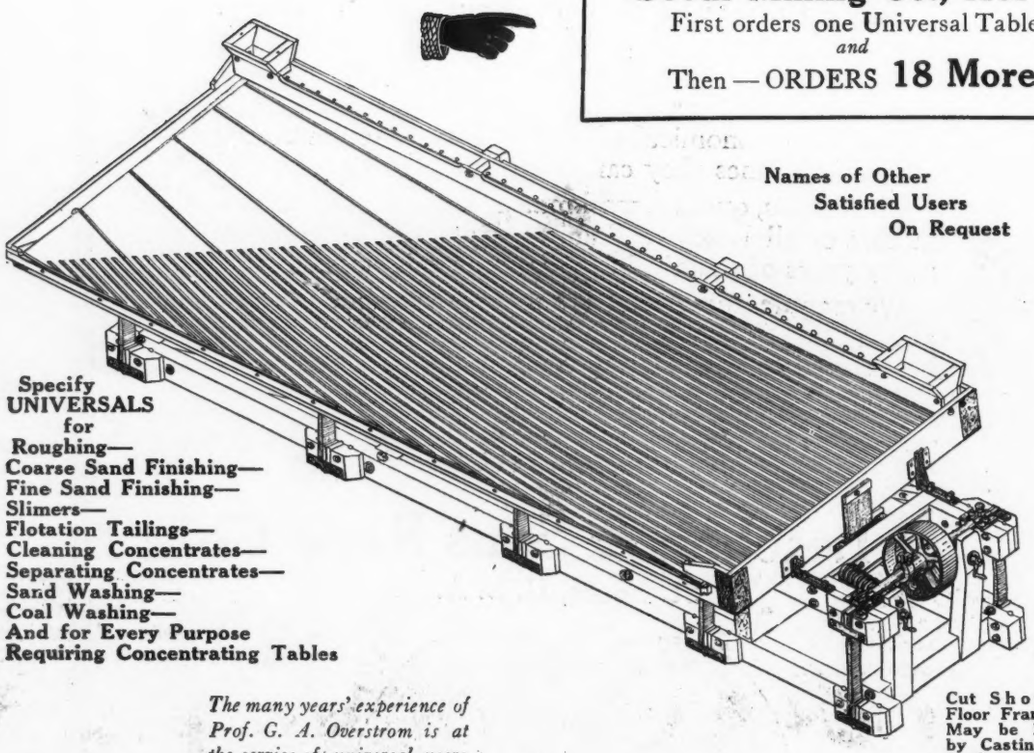
*Strong*
*Safe*
*Durable*

# In Foreign Fields—

**Here's more evidence of what they think of**

## OVERSTROM UNIVERSAL CONCENTRATORS

**Seoul Mining Co., Korea**
First orders one Universal Table
*and*
Then — ORDERS **18 More**



**Names of Other Satisfied Users On Request**

**Specify UNIVERSALS for**
**Roughing—**
**Coarse Sand Finishing—**
**Fine Sand Finishing—**
**Slimers—**
**Flotation Tailings—**
**Cleaning Concentrates—**
**Separating Concentrates—**
**Sand Washing—**
**Coal Washing—**
**And for Every Purpose Requiring Concentrating Tables**

*The many years' experience of Prof. G. A. Overstrom is at the service of universal users*

**Cut Shows Wood Floor Frame, Which May be Eliminated by Casting Pockets for Legs in Concrete Foundation.**

**EXPORT INQUIRIES**
**For Prices and Information Should Be Addressed To**

## OVERSTROM & SONS, ENGINEERS

**2416 McPherson St., Los Angeles, Calif., U. S. A.**

# The Telsmith Bolt-Shaft Breaker

***Advertisement No. 1***

The Telsmith Breaker is frequently referred to as the "short crusher," because it is thirty per cent. lower than even the "short crushers" which have recently emerged into publicity. This low structure is a big advantage. For instance, it almost doubles the strength of the frame, shaft and crown. Then again, as all repairs are made from above the breaker, the conveyor or elevator can be run directly under it, making a big saving in mill height. There is also an important saving in over-head clearance, due to the short shaft.

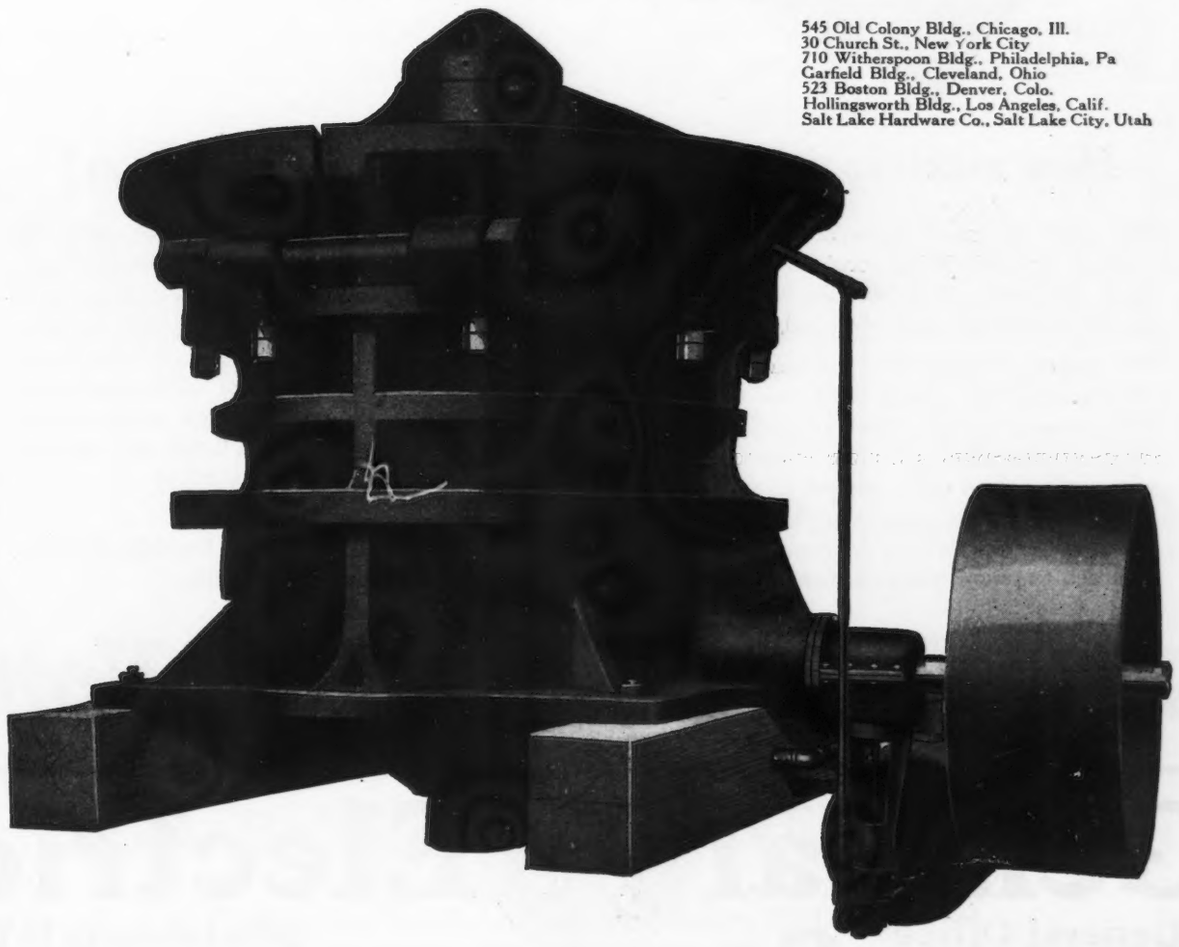
BUT—the chief advantage of Telsmith pillar-shaft design is not its short structure, but its parallel crushing stroke. The head gyrates horizontally, the "pinch" being the same at top and bottom of the bowl. It will grip even hard, smooth boulders without slippage or rocketing. The effectiveness of the straight, horizontal "bite" is not merely a theory. It is proven every day in the year at Braden Copper Co., Rancagua, Chile; Penn Iron Mining Co., Vulcan, Mich.; Liberty Bell Gold Mine, Telluride, Colo.; United Eastern Mining Co., Oatman, Ariz.; Barnes-King Development Co., Marysville, Mont.; Kennecott Copper Co., Latouche, Alaska; Thomas Iron Co., Wharton, N. J., and in hundreds of other plants all over the world.

Glad to send you our catalog No. 168 covering the Telsmith Breaker or our Bulletin No. 2-F-1, covering the Telsmith Reduction Crusher. Write for them.

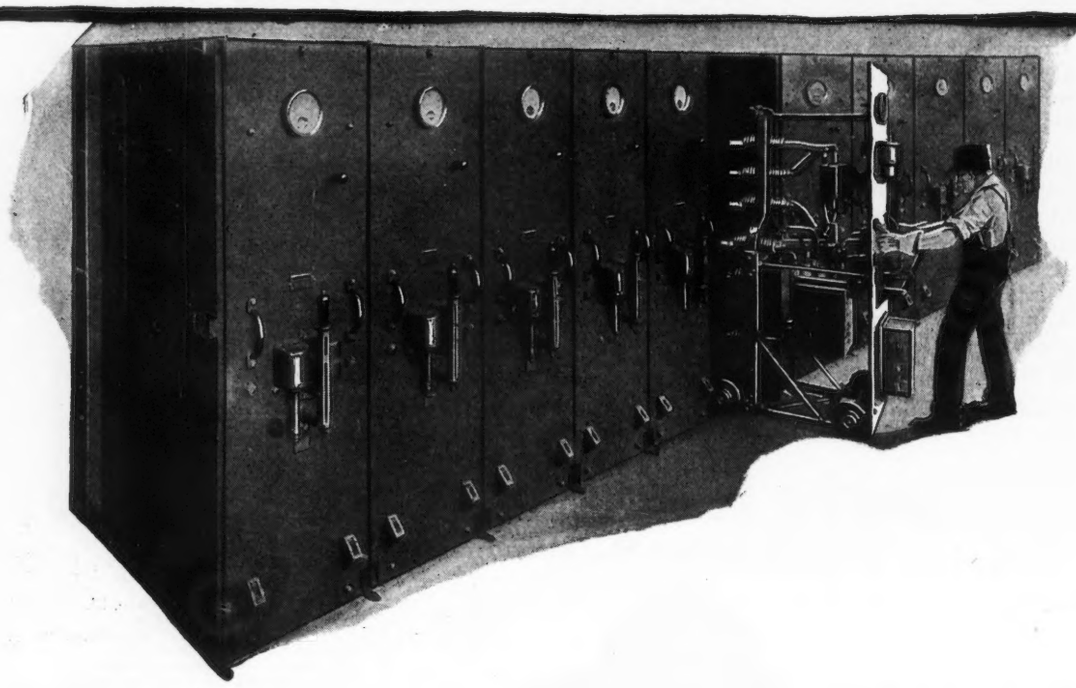
## SMITH ENGINEERING WORKS

**3195 Locust St., Milwaukee, Wis.**

545 Old Colony Bldg., Chicago, Ill.
30 Church St., New York City
710 Witherspoon Bldg., Philadelphia, Pa
Garfield Bldg., Cleveland, Ohio
523 Boston Bldg., Denver, Colo.
Hollingsworth Bldg., Los Angeles, Calif.
Salt Lake Hardware Co., Salt Lake City, Utah



***A switchboard that will prevent little troubles becoming great losses is worth building and standardizing***



## How much is uninterrupted operation worth to you?

The profit of many operations and processes depends on their being continuous. Interruptions dislocate schedules, disorganize departmental operations and start other difficulties.

To prevent interruptions, originating at the switchboard, the remedy is to use G-E Truck Switchboard Units. They reduce the probability of interruptions to the minimum. If an interruption does occur, substitution of a spare truck of the proper capacity makes it possible to maintain service which, in most cases, can be regarded as practically continuous.

These movable trucks, as illustrated, carry all the instruments, switching and protective devices. By mounting this equipment on a truck, which can be withdrawn only when this apparatus is dead, electrically, inspection is easy and safe. Complete enclosure of all live current-carrying parts within the steel compartment affords personal safety at all times and reduces fire risk.

Consult the G-E Switchboard Specialist in your vicinity. Write our nearest office.

84-19

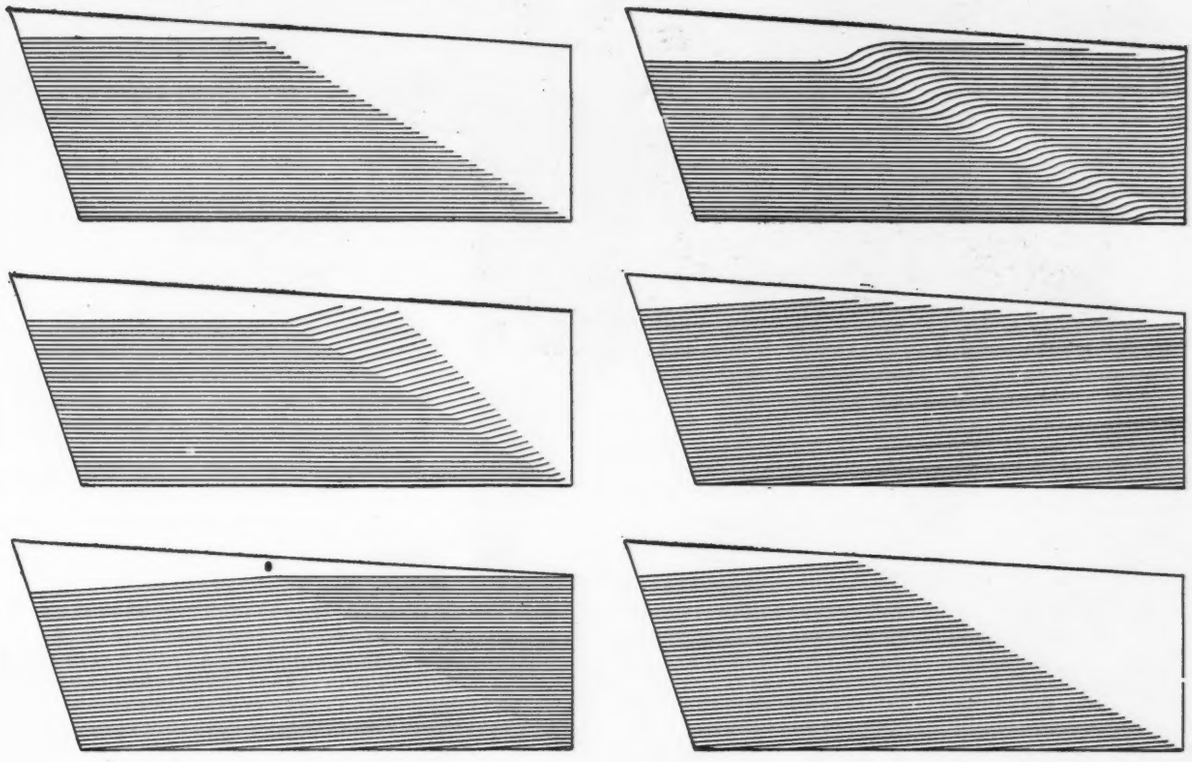
**G-E Truck Type Switchboard Units**

**General Electric Company**

General Office Schenectady, N.Y.

# BUTCHART TABLES

## *The* NEW No. 7 *is the Best Low-Priced Table on the Market*



These are a few of the many types of Riffling which can be used.

Any specified form of Riffling will be furnished.

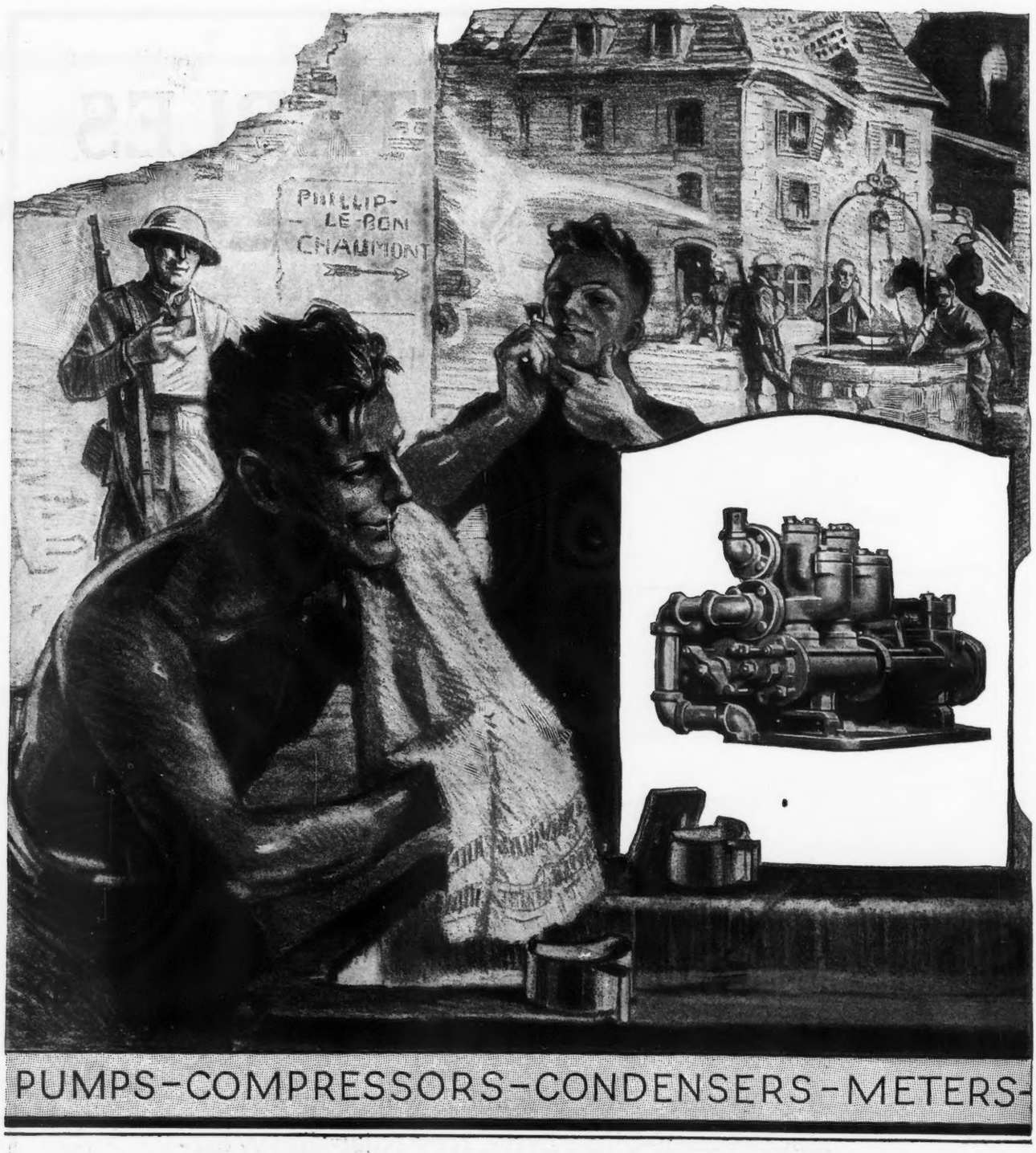
Enclosed Self-Oiling Drive, New Rust- and Wear-Proof Adjusting Mechanism.

The New No. 7 is light weight, strong, durable and priced right.

## W. A. BUTCHART, DENVER, COLO.

*Eastern Representative*

**A. P. Watt 52 Vanderbilt Avenue, Room 1903, New York**




PUMPS-COMPRESSORS-CONDENSERS-METERS-

# WORTHINGTON

Worthington Works
*Harrison, N. J.*
Blake & Knowles Works
*East Cambridge, Mass.*
Deane Works
*Holyoke, Mass.*
Hazleton Works
*Hazleton, Pa.*

# Even when they shaved Worthington helped

'SHOES shined and faces shaved''—if any one phrase from the orders of the day will be remembered, that is it.

With the American soldier the morning shave was a habit, even under fire, so Worthington's part in making razor blades at once assumes a peculiar importance.

And while Worthington compressors and vacuum pumps in South Boston were helping to make razor blades, other Worthington equipment was playing its part in factories making soap, steel mirrors, brushes, and indeed practically everything that went into the recruit kit.

It is significant of Worthington's ability to meet emergencies that, although the eight Worthington factories were all delivering unprecedented quantities of war materials, it was still possible for them to supply the wants of those industries essential to everyday life.

WORTHINGTON PUMP AND MACHINERY CORPORATION
*Executive Offices:* 115 Broadway, New York City
*Branch Offices in 24 Large Cities*

OIL & GAS ENGINES—MINING MACHINERY

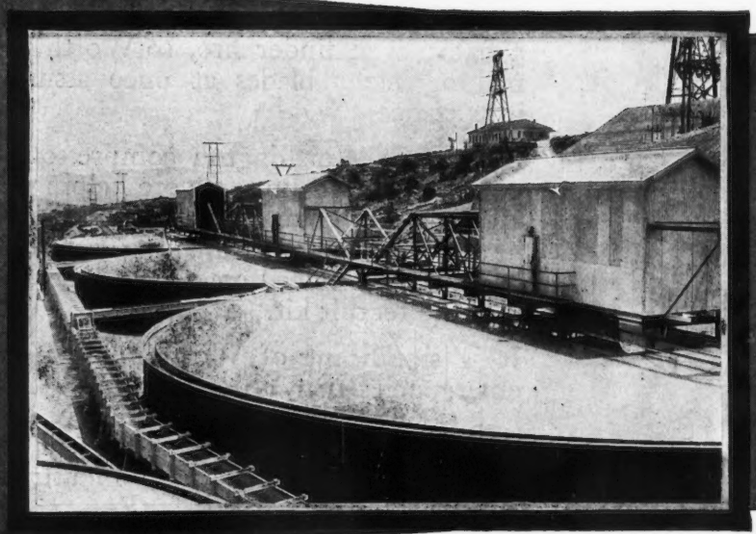
# WORTHINGTON

Snow-Holly Works
*Buffalo, N. Y.*
Laidlaw Works
*Cincinnati, Ohio*
Power & Mining Works
*Cudahy, Wis.*
Gas Engine Works
*Cudahy, Wis.*

# EVIDENCE OF SATISFACTION

"No better service could possibly be asked of any machine than that obtained from your Thickeners. We have four of them. The density of the pulp discharged varies from 23% to about 30% moisture, average one period .263 "

"Your letter of the 20th inst , regarding the 200-foot Thickener can be answered by the word 'No' There was no trouble in erecting, nor has there been any in operation."



DORR

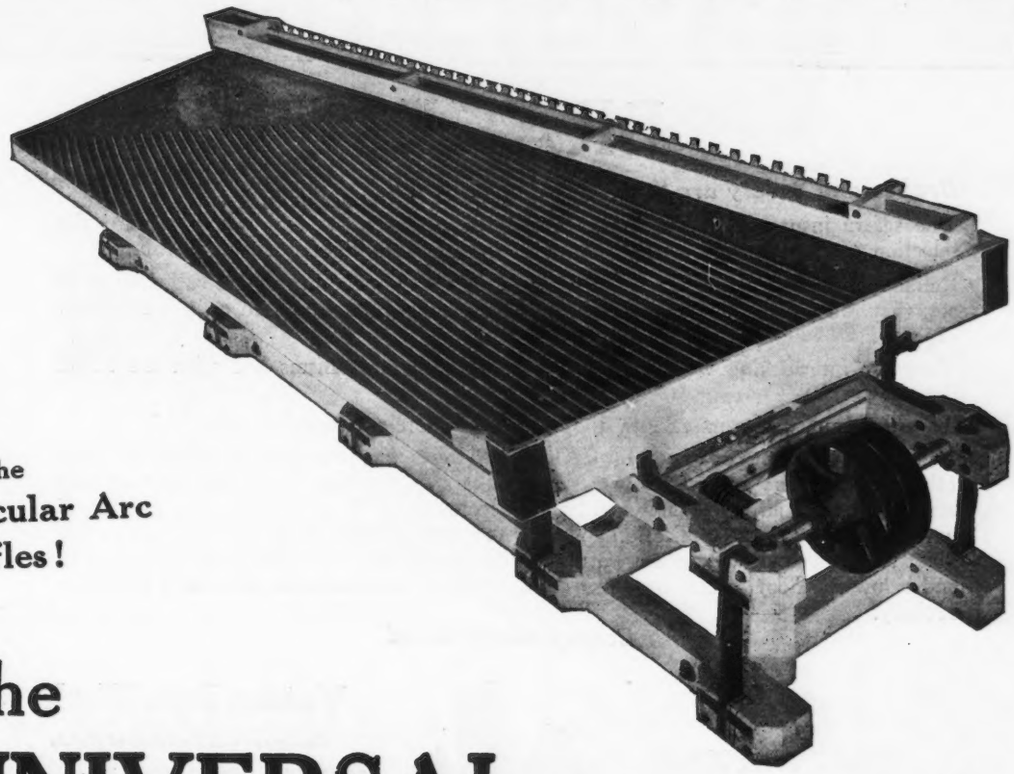
DORR

"In all the years we have used your Thickeners, we have never had one stick, nor have we had any breakage. We find that a 1 H P motor drives two 22-foot Thickeners with great ease "

"If ALL our equipment gave us the service of Dorr products the cares of our operators would be nil It is so seldom one buys machinery that really lives up to every claim made for it, that it is a pleasure to co-operate with the manufacturer, and we will gladly give you any information you may ask for in regard to your machines."

THE DORR COMPANY ENGINEERS

NEW YORK · LONDON
101 PARK AVE. 16 SOUTH ST.
DENVER
1009 17TH ST.



Look
for the
**Circular Arc Riffles!**

# The UNIVERSAL Concentrating Table

## Eccentrics are Eliminated

**by the Weighted Pulley Head Motion, the Most Radical Improvement in Table since the use of riffles.**

**There are no wearing surfaces and joints to be kept in adjustment. The skilled mechanic is superfluous.**

## A Snappy, Live Action is Produced

**This is impossible with any combination of eccentrics, cams, toggles, etc. This snappy Action Settles, Stratifies, Separates and Discharges the concentrates at a speed hitherto undreamed.**

## And It Is So Simple!

**One operator writes:—"aside from all other considerations, the Simplicity of the UNIVERSAL is of such importance that the operator Cannot Afford to Consider the use of Any Other Table."**

**Its Recovery is as Superior as its Simplicity**

**Insist upon the Weighted Pulley Head Motion**

---

## Overstrom Manufacturing Co.

**1217J First National Bank Building**
**San Francisco**

VULCAN

# BRAKES

***Brakes and Safety are "next of kin" on a hoist.***

The safety insurance of the brakes on VULCAN Hoists, does not stop with the selection of a "post type brake," nor with the use of a high grade brake lining.

Reliable automatic action is necessary for safety. When the brakes are called upon to act, they must go on at once, and further, they must hold—they do on a VULCAN Hoist.

They are interlocking with the starting and clutch mechanisms and with the travel limit device.

The sole penalty of a mistake by the operator is merely a complete stop.

Other safety features of brakes on VLLCAN Hoists are: provision for taking up wear (this may be done automatically); slack brake switch which forces operator to keep brakes in proper adjustment (when brakes become worn too much for safety, they lock until adjusted); break application governor to secure gradual instead of abrupt stop (of great value on slopes where momentum of train might carry cars over rope and cut it); and below the floor counterweights (see the fifth of this series of talks on VULCAN Hoists).

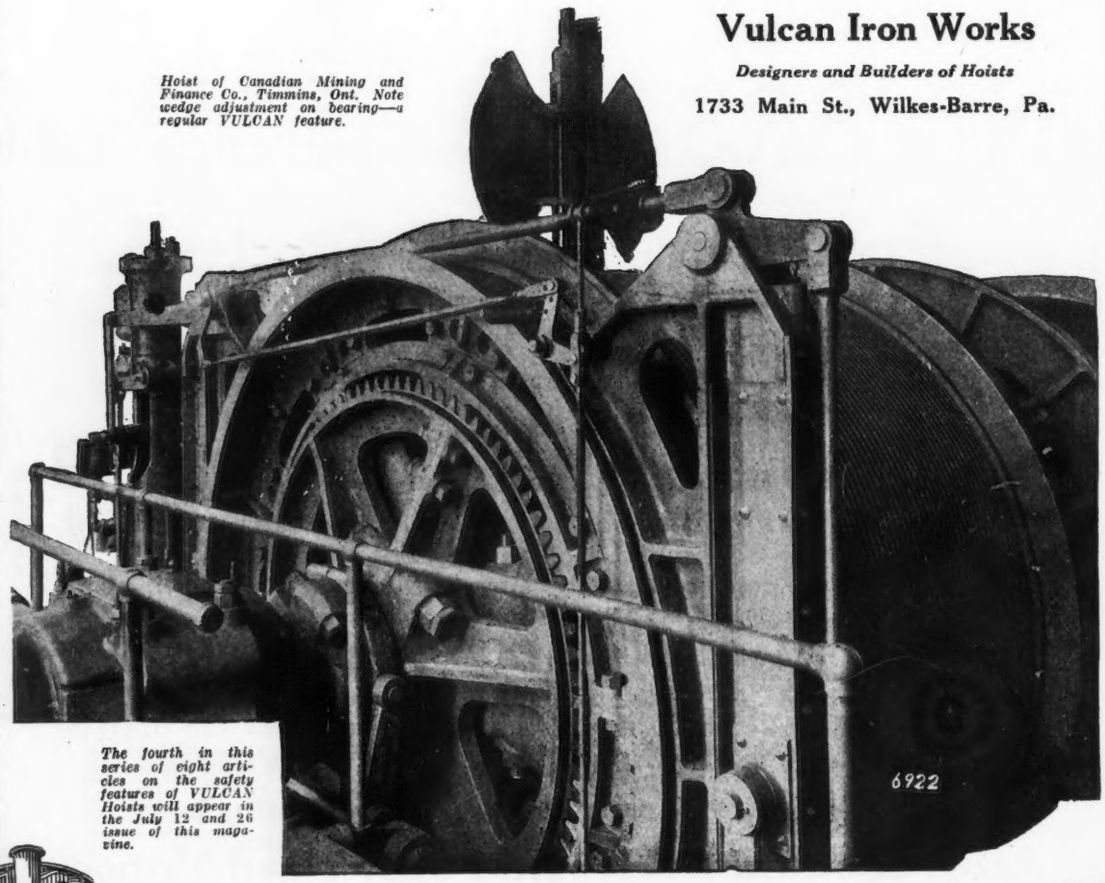
*Correspondence invited*

**Vulcan Iron Works**

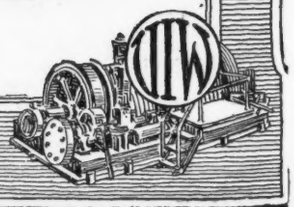
***Designers and Builders of Hoists***

**1733 Main St., Wilkes-Barre, Pa.**

*Hoist of Canadian Mining and Finance Co., Timmins, Ont. Note wedge adjustment on bearing—a regular VULCAN feature.*

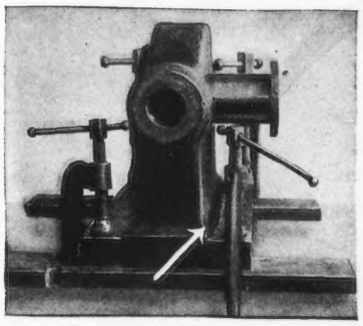


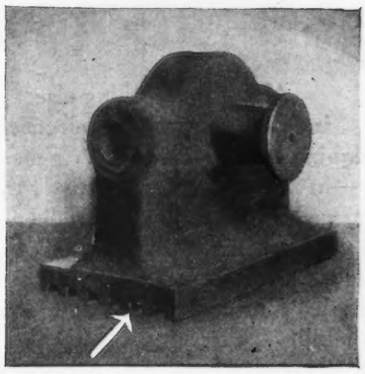

*The fourth in this series of eight articles on the safety features of VULCAN Hoists will appear in the July 12 and 26 issue of this magazine.*

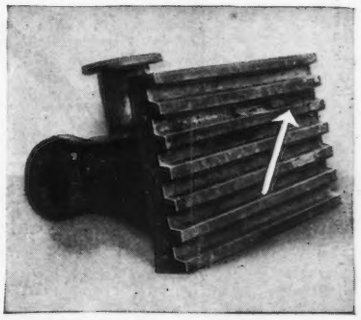


VULCAN

Oxweld







# A Bad Break in a Bad Spot

These three pictures are a movie showing the progress of a valuable compressor crosshead saved from the scrapheap and ready to go back into service.

Oxweld Equipment did the job—quickly, cheaply, permanently.

The Oxweld Injector Type Blowpipe saves gas, saves time, saves disappointment—gives 100% results for the skill you put into your jobs.

169

**OXWELD ACETYLENE COMPANY**

**NEWARK, N. J. CHICAGO LOS ANGELES**

***World's Largest Maker of Equipment for Oxwelding and Cutting Metals***

VULCAN

# BRAKES

***Brakes and Safety are "next of kin" on a hoist.***

The safety insurance of the brakes on VULCAN Hoists, does not stop with the selection of a "post type brake," nor with the use of a high grade brake lining.

Reliable automatic action is necessary for safety. When the brakes are called upon to act, they must go on at once, and further, they must hold—they do on a VULCAN Hoist.

They are interlocking with the starting and clutch mechanisms and with the travel limit device.

The sole penalty of a mistake by the operator is merely a complete stop.

Other safety features of brakes on VLLCAN Hoists are: provision for taking up wear (this may be done automatically); slack brake switch which forces operator to keep brakes in proper adjustment (when brakes become worn too much for safety, they lock until adjusted); break application governor to secure gradual instead of abrupt stop (of great value on slopes where momentum of train might carry cars over rope and cut it); and below the floor counterweights (see the fifth of this series of talks on VULCAN Hoists).

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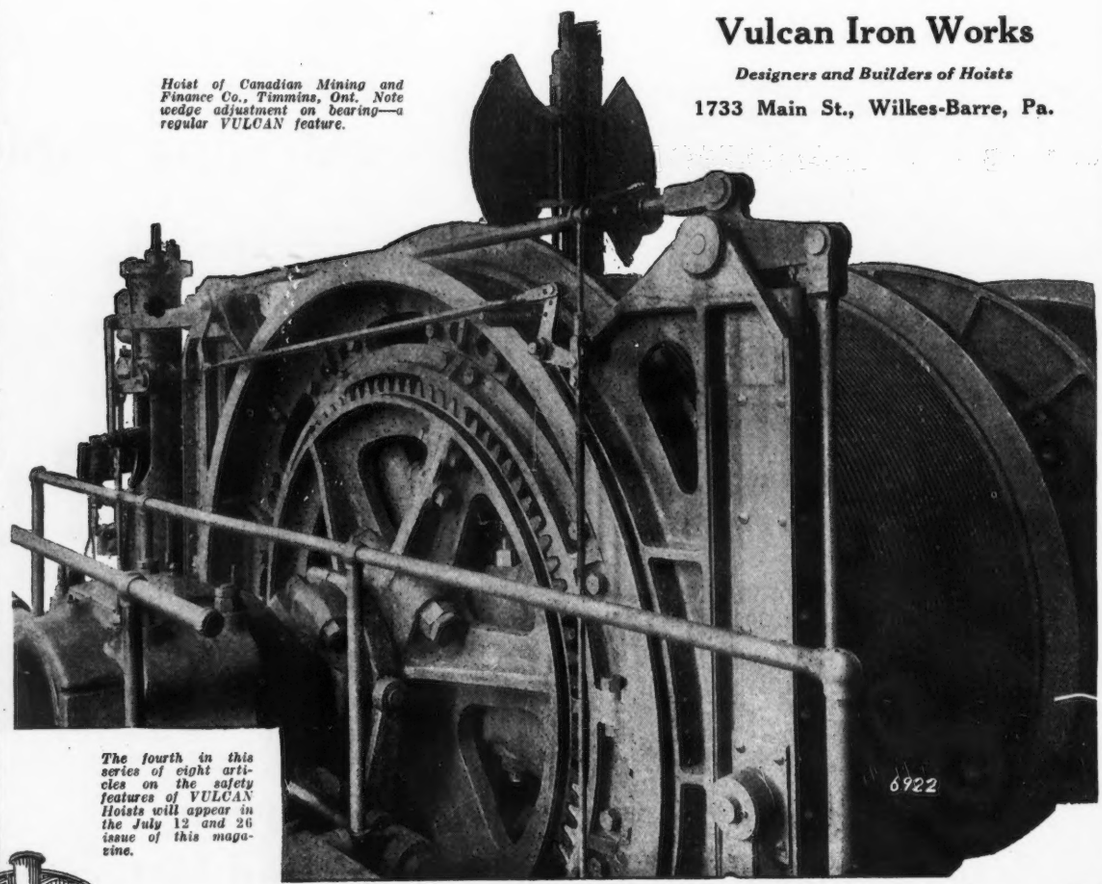


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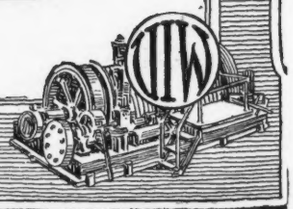
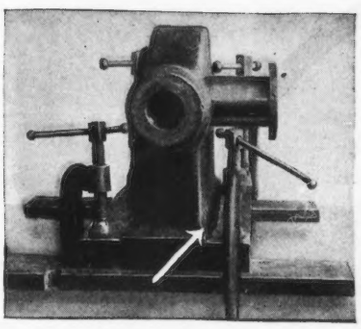
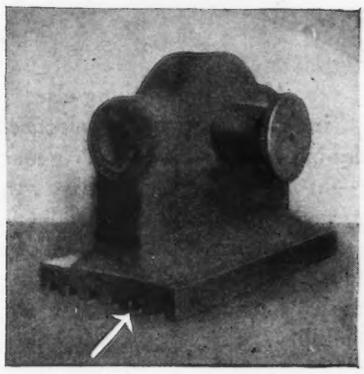
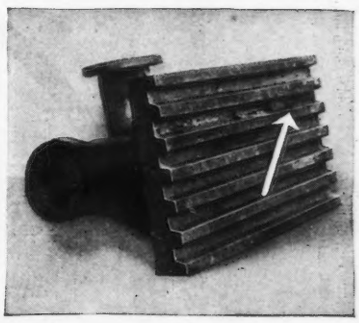


VULCAN

Oxweld







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169

OXWELD ACETYLENE COMPANY
NEWARK, N. J. CHICAGO LOS ANGELES

*World's Largest Maker of Equipment for Oxwelding and Cutting Metals*

# Electrical Reliability in your Ore Handling

Above everything else in the selection of electrical equipment for ore handling machinery—in importance, even greater than the advantages of motor drive itself—is the reliability of the motor and control—both mechanically and electrically.

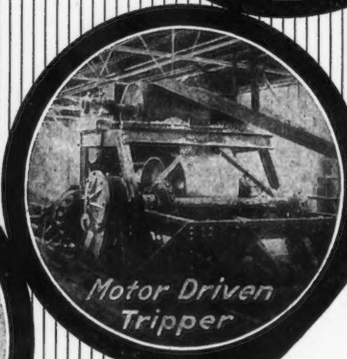
Strength of material alone does not necessarily imply reliability. Experience with the problems of operation is necessary to produce successful equipment. Westinghouse engineers have spared no expense in studying the actual requirements of ore handling operations. It preceded and formed the basis of our designs. Westinghouse engineers are constantly in active touch with mining operations, both metal and coal, and this operating experience permits embodying in our designs, continual improvements that increase the speed, reliability, and economy of handling ore electrically.

Electrically Operated Car Tipple

Hulett Type Tailings Excavator

W
WESTINGHOUSE ELECTRIC

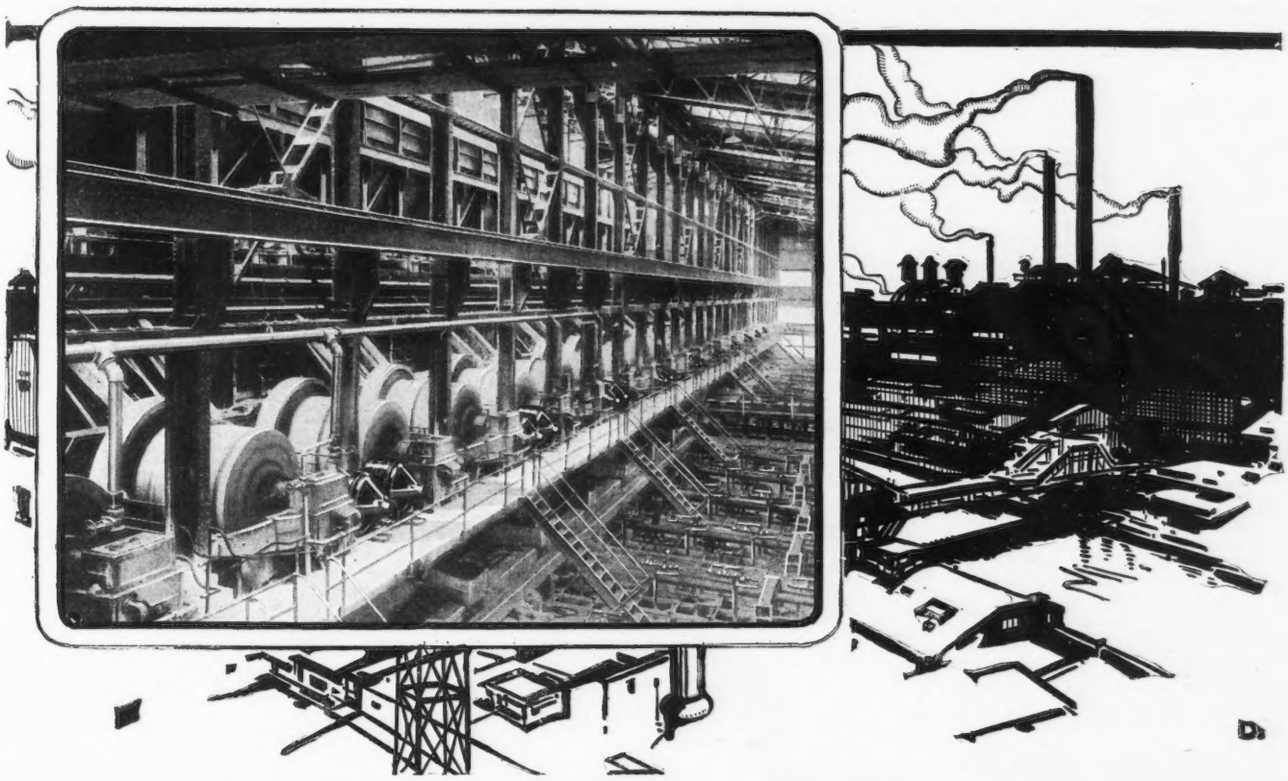
Motor Driven Conveyers and Distributers


Motor Driven Tripper

Electrically Operated Shovel Loading Electrically Propelled Ore Train.

# Westinghouse

*Electric power equipment when properly applied is eliminating shutdowns and thereby boosting production in metal mines the world over.*



# G-E Motors Keep Mills Running

Mills that require nearly double power at starting and run continuously in moist, gritty air, are being driven by G-E motors.

The splendid operating records of these motors in this service are used as a basis for repeat orders when extensions are planned which require dependable, heavy-duty motors.

Scores of G-E motors drive mills at leading mining companies throughout the country.

Our engineers will be glad to show you why.

***Write our nearest office for bulletins or Electric Power in Metal Mining***

**General Electric Company**

**General Office Schenectady, N.Y.**

43-238

POSITIONS VACANT

# EMPLOYMENT

POSITIONS WANTED

## POSITIONS VACANT

SUPERINTENDENT wanted by Eastern lead smelting and refining works. Good opportunity for energetic man experienced in this line, possessing also some knowledge of copper smelting. Address stating particulars and salary expected. P-562, Eng. & Min. Journal.

## EMPLOYMENT AGENCIES

POSITIONS Secured Promptly for well qualified men in all branches of mining and metallurgical work. 16 Years established clientage with largest companies in the industry. Business-Men's Clearing House, Denver, Colorado.

**Employment Service**

The undersigned provides a confidential service designed to locate openings through correspondence for men earning not less than $2,500 and up to $25,000; all lines. Not an employment agency, but a constructive. initiative service, covering individual negotiations. Established 1910. Complete privacy assured; present connections in no way jeopardized. Send name and address only for explanatory details. R. W. Bixby, 308 Lockwood Bldg., Buffalo, N. Y.

## POSITIONS WANTED.

AGGRESSIVE and forceful engineer, age 33, of wide experience in management of successful mines and mills of base and precious metals; formed strong connections in exploration, appraisal of mines, and ore dressing investigations in Canada and the United States; desires to negotiate with responsible consulting firms, and operating mines for foreign or home service. PW-534, Eng. & Min. Journal, Leader-News Bldg., Cleveland.

A PROSPECTOR and clean-up man of 40 years' experience wishes to form a business connection with investor or company; gravels, mill tailings, base ores; all the metals and commercial minerals and three probable dredging localities; platinum, tungstein and molybdenum. For terms address PW-543, Eng. & Min. Journal.

COAL mining superintendent, 36 years old, married, technical training, 8 years' practical experience; 3 years as head executive of large coal operation. Open for engagement. Personal interview. PW-228, Eng. & Min. Journal, Philadelphia.

MAN, 45 years of age, with 20 years' experience as master mechanic of smelters and superintendent of machine shops, desires position, preferably west. PW-542, Eng. & Min. Journal, Chicago.

## EMPLOYERS

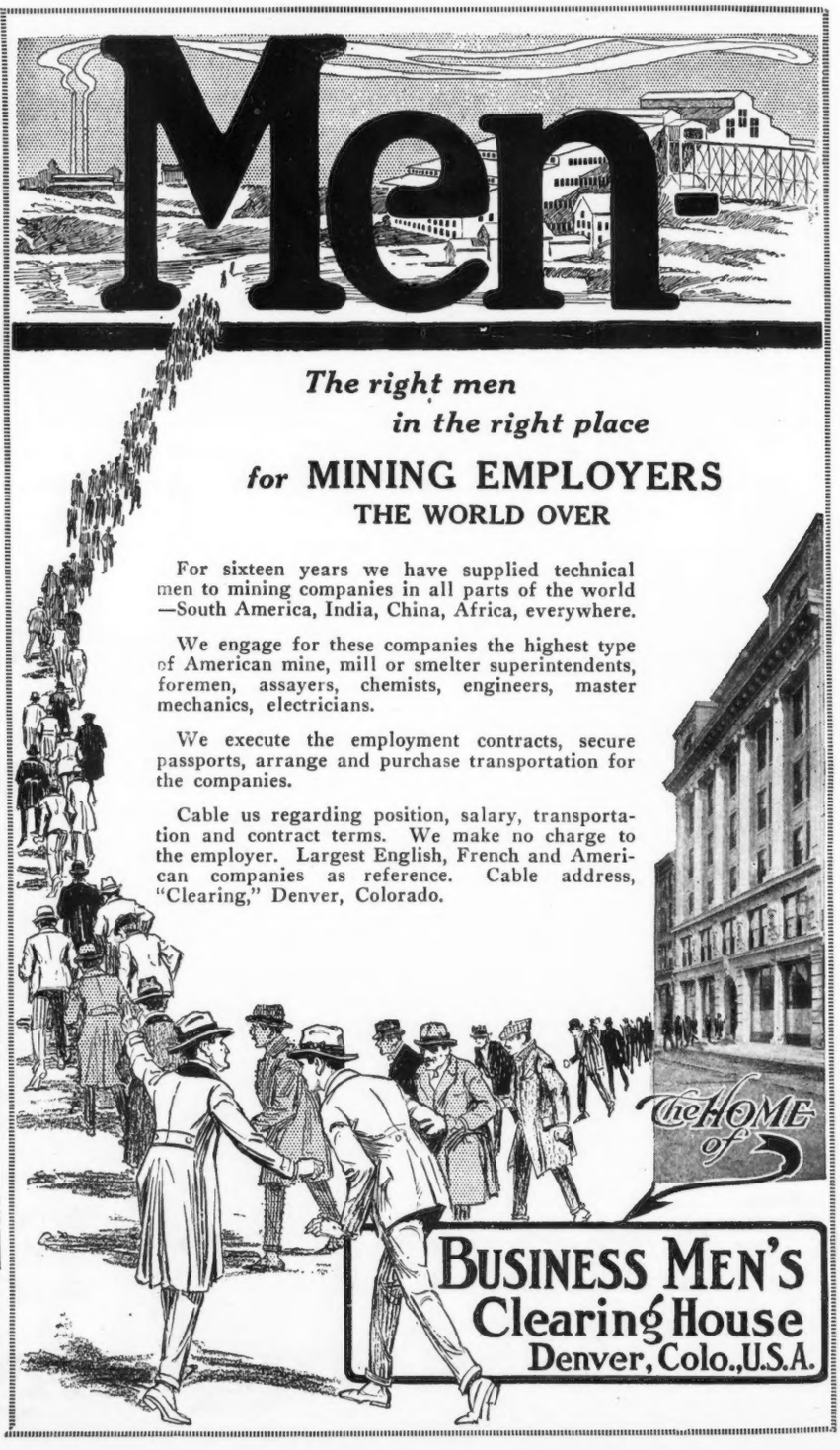
Send us your inquiries for men of technical training and experience. We are obtaining employment for soldiers, sailors and marines released from the service.
Re-Employment Bureau of New York City for Soldiers, Sailors and Marines, 505 Pearl Street, north of Municipal Building, Professional Section. Worth 9250.

## POSITIONS WANTED

MINING engineer; technical graduate; twelve years' experience; examinations, explorations and developments; design and construction mining and milling plants; capable executive; desires position of responsibility. PW-557, Eng. & Min. Journal.

## POSITIONS WANTED

MINING engineer, 31; married; technical graduate; 10 years experience in mine development and operation, mill construction and operation open for engagement as engineer or superintendent. Best references from present employers. PW-561, Eng. & Min. Journal.



Men.
The right men
in the right place
for MINING EMPLOYERS
THE WORLD OVER
For sixteen years we have supplied technical men to mining companies in all parts of the world —South America, India, China, Africa, everywhere.
We engage for these companies the highest type of American mine, mill or smelter superintendents, foremen, assayers, chemists, engineers, master mechanics, electricians.
We execute the employment contracts, secure passports, arrange and purchase transportation for the companies.
Cable us regarding position, salary, transportation and contract terms. We make no charge to the employer. Largest English, French and American companies as reference. Cable address, "Clearing," Denver, Colorado.
The HOME of
BUSINESS MEN'S
Clearing House
Denver, Colo., U.S.A.

# Get Your Wants into the Searchlight

## ADVERTISING RATES

### Ads Set in Uniform Style

*(Solid, in one paragraph, without display)*

**THREE CENTS A WORD**, minimum charge 50 cents an insertion, payable in advance, less 10 per cent, if one payment is made in advance for four continuous insertions—for advertisements under:

| | |
|---|---|
| Positions Wanted | Vacation Work Wanted |
| Evening Work | Tutoring |
| Wanted | Salesman Wants Connections |

**FIVE CENTS A WORD**, minimum charge $1.50 an insertion, for advertisement under:

| | |
|---|---|
| Agencies Wanted | Positions Vacant |
| Agents Wanted | Partner Wanted |
| Business Opportunities | Representations Wanted |
| Desk Room for Rent | Salesmen Wanted |
| Educational | Patents for Sale |
| Employment Agencies | Plants for Sale |
| Desk Room Wanted | Sub-Contracts Wanted |
| Foreign Business | Work Wanted |

Miscellaneous for Sale, for Rent or Want Ads.

**THIRTY CENTS A LINE**, minimum five lines, for all undisplayed advertisements set with a paragraph for each item or tabulated.

**THREE DOLLARS AND SIXTY CENTS AN INCH** for advertisements for bids (Official Proposals).

### Ad Set in Display Type

*(Individual space, within border rules)*

Space for these advertisements is sold by the inch. Each page contains 30 inches. The rate per inch is based on the *total* number of inches to be used—that is, the number of inches the advertisement is to occupy multiplied by the number of insertions it is to receive. For instance, a 2-inch advertisement in 2 issues earns the 4-inch rate of $2.90 an inch. A 1-inch space in 4 issues, or a 4-inch space in one issue, also earn the 4-inch rate.

SCHEDULE OF RATES

| | |
|---|---|
| 1 to 3 in., $3.00 an in. | 15 to 26 in., $2.70 an in. |
| 4 to 7 in., 2.90 an in. | 27 to 49 in., 2.60 an in. |
| 8 to 14 in., 2.80 an in. | 50 to 99 in., 2.50 an in. |

Rates for larger space furnished on request

*For quick and satisfactory results tell the reader everything that he will want to know.*

## INFORMATION

**ALLOW FIVE WORDS** for the address, if repile are to a box number in care of any of our offices There is no extra charge for forwarding replies.

**IN REPLYING TO ADS.** do not enclose original testimonials or anything that you may want returned. State your experience and qualifications in as concise and neat a manner as possible and enclose copies of you. testimonials.

**BE CAREFUL TO PUT ON ENVELOPE**, when answering any "blind" ad, the box number in the ad, the name of the paper, and also the local address of office to which reply is sent:

| | |
|---|---|
| 36th St., at 10th Ave., | New York |
| 935 Real Estate Trust Bldg., | Philadelphia |
| 657 Leader-News Bldg., | Cleveland |
| 1570 Old Colony Bldg., | Chicago |
| 501 Rialto Bldg., | San Francisco |

**WHEN ADVERTISING MACHINERY**, use your own name and address—or a local address of some kind—so that the readers can wire direct and get quick replies. We advise also that you state in your advertisement the present location of plant that is offered for sale, or point of delivery provided you are in the market for equipment.

**TO SIGN YOUR NAME** and address to your advertisement begets the confidence of the reader and facilitates receiving replies. You can, however, obviate delay in receiving answers by signing your ad. only with initials (your own or others), care of your home, your office or a post-office box number in your city.

## POSITIONS WANTED

MANAGER, captain engineers, resigned; 42 years; married; technically trained; wide experience covering 20 years' management, mining and ore dressing in United States and Latin-America. Experienced efficiency engineer and blast furnace management. Speak Spanish. Highest references as to ability and integrity. Address General Manager, Crimora Mines, Crimora, Virginia.

GRADUATE mining engineer, (34); member A. I. M. E., desires position mine superintendent; 13 years' experience in iron, gold, copper and pyrite mining in United States and Canada; holding responsible executive positions, mining engineer and mine superintendent. Best references, can go anywhere but prefer location in Canada. At present engaged; desires change; minimum salary, $3600. PW-527, Eng. & Min. Journal, Leader-News Bldg., Cleveland.

## POSITIONS WANTED

MINING engineer; technical training and several years' experience; desires position as assistant surveyor or assayer. At present employed; available after June 20th. Age, 29. Married. Thoroughly competent along above lines. PW-538, Eng. & Min. Journal, Rialto Bldg., San Francisco.

MINING engineer, recently discharged army officer, technical graduate, 11 years' excellent experience, is available for enination, exploration and development gagement. Especially qualified for examination, exploration and development work. Age 33. Speak Spanish. Best references. W. E. B., 3142 Harvey Ave., Cincinnati, Ohio.

POSITION as manager of mine, mill and exploration work wanted; salary of $10,000 per year, by one who can earn same. PW-550, Eng. & Min. Journal, Chicago.

## POSITIONS WANTED

MINING engineer with 25 years' experience, including mine and works operation, construction plant installation and mine examination, is open for engagement as manager or general superintendent. PW-556, Eng. & Min. Journal.

CAPABLE mine manager or superintendent, with or without efficient operating organization for hard rock metal mines open for engagement owning to cessation of war production. Desire permanent situation with large company; location immaterial. PW-544, Eng . & Min. Journal. Chicago.

ELECTRICAL engineer, just the man you want, invites your correspondence; six years' shop, installation, construction, maintenance, planning; one year coal mine electrification. French, Spanish; domestic or foreign service; now first lieutenant commanding engineer horse and motor transport., A. E. F. Free about July 1st. PW-560, Eng. & Min. Journal.

ECONOMIC geologist connected with the geological department in leading technical school as a special lecturer, can devote part of his time to outside work. Experience in coal and oil examinations; topographic mapping, geologic mapping both surface and underground, tropical explorations, both metalliferous and nonmetalliferous. PW-235, Eng. & Min. Journal.

CONSTRUCTION engineer, with excellent knowledge of mechanical-electrical construction about mines and mills desires position. Can build anything, supervise complete job from start to finish. Graduate electrical engineer with four years record in railway work, mine electrification, mill construction and industrial works; 27 years old, single, speak fair Spanish, will go anywhere. Immediately available. M. C. Mellinger, 12 Madison St., San Antonio, Texas.

## *Does any reader of Engineering and Mining Journal know of a man who can fill this job?*

There is a vacancy in our mail order circulation department. It is a position that calls for a thorough acquaintance with the metal-mining field—its men, its conditions, its problems, its possibilities. Advertising or selling experience is desirable, but not strictly necessary, if such a man has the instincts of a salesman, is a ready writer and a deep digger, and can develop into a builder of convincing letters and circulars. There will be a fair salary to start, with possibilities limited only by what the man can make of himself and his job.

***If you know of such a man, Engineering and Mining Journal will appreciate your putting it into touch with him at once. Better still, have him write to us with a full statement of his experience, together with age and salary expectations.***

***Address:*** **McGraw-Hill Co., Inc.,** 10th Ave., at 36th St., New York
**Attention, Mr. Bope**

### In Replying to "Blind" Ads

be careful to put on envelope the key number in the ad. and also local address of office to which reply is sent.

10th Ave. at 36th St., New York.
935 Real Estate Trust Bldg., Phila.
657 Leader-News Bldg., Cleveland.
1570 Old Colony Bldg., Chicago.
501 Rialto Bldg., San Francisco.

### Important

Original letters of recommendation or other papers of value should not be enclosed to unknown correspondents—send copies.

## POSITIONS WANTED

SUPERINTENDENT or manager open to engagement; graduate mining engineer of large experience in the details of mine development and operation, milling, cyaniding, concentration, mechanical lines. Capable executive. PW-551, Eng. & Min. Journal.

## AGENTS AND SALESMEN

**Representation Solicited**

Salesmen and owners of warehouses in Cleveland, Ohio, wish to represent smelters or producers of copper, lead and zinc ingot, in Cleveland and surrounding territory on commission basis. AS-555, Eng. & Min. Journal, Chicago.

**Do You Want Representation in Great Britain?**

English ex-officer with London offices and 12 years' experience English markets is now in an ideal position to represent American manufacturers of high-class specialties. Electrical or mechanical. Write Box 806, c/o Hooper & Batty, Ltd., 15 Walbrook, London E. C. 4, England.

## WANTED

**Used Carbon (Black Diamonds) and Bortz** and fragments wanted; will pay highest prices. S. Dessau's Son, 180 Broadway, New York, N. Y.

**Maurice S. Dessau, 6 Maiden Lane, N. Y.** will pay highest prices for carbon (black diamonds) and Bortz fragments, also large and small used stones. Payment made return mail for merchandise purchased.

## FOR SALE

**Dolomite Limestone, Dolomite Gravel**

For sale for fluxing ore, road material, refining wood pulp, concrete rock, etc. W. F. Cooper, Box 584, Sault Ste. Marie, Mich.

# DIAMOND LABOR AGENCY

furnishes first-class laborers and tradesmen for all classes of trade and labor, best of machinists, helpers and all classes of tradesmen; skilled and common laborers, foreign and American, supplied free of charge to employers of labor anywhere.

**Diamond Agency, 557 West Madison St., Chicago, Ill.**
'Phone Main 5074

## MISCELLANEOUS

**A Study Mineral Collection**

115 specimens, good sized and each specimen with label adhered. Every important mineral specie represented. The best mineral collection ever sold at the low cost of $28.50 delivered. Send for pamphlet. I buy choice mineral specimens of any kind. Mineral collections for sale. Mineral collections bought. G. S. Scott, 20 Nassau St., New York.

## Petrographic Slides and Rocks

To Mining Engineers:

25 Cents in stamps will bring you a copy of a new Descriptive Catalog of Cripple Creek Rocks, giving a petrographic interpretation of the Rocks.

$20.00 will bring you a set of 21 Microscope Slides of Thin Sections of these rocks of best workmanship.

Send also for our Price-List of Rocks; over 500 varieties scientifically labeled.

**Ward's Natural Science Establishment**
Department of Mineralogy and Petrography
George Letchworth English, Manager,
84-102 College Ave., Rochester, N. Y.

## OFFICIAL PROPOSALS

Bids: July 23.

### Coal Crusher

LIGNITE UTILIZATION BOARD OF CANADA
CREATED BY THE DOMINION GOVERNMENT
BY ORDER IN COUNCIL
80 S. FRANCOIS XAVIER ST.
Montreal, P. Q.

The above Board will receive tenders for a coal crusher until 12 o'clock noon, July 23rd, 1919, and for coal drying equipment until 12 o'clock noon, July 30th, 1919.

Specifications and full information may be obtained upon application to the Secretary of the Board. A charge of $2.00 each will be made for copies of specifications, which sum will be refunded to bona fide tenderers or upon the return of the specifications.

The Board does not bind itself to acept the lowest or any tender.

R. A. ROSS,
Chairman.
LESLIE R. THOMSON,
Secretary.

## GET YOUR WANTS INTO THE SEARCHLIGHT

# Business Opportunities

**Capital — Partners — Plants — Shops — Properties — Mines**

**Gold and Silver Property**

Six mining claims in the Mogollon mineral belt three miles south of the town of Mogollon. A good wagon road traverses the property the entire length and connects with the Mogollon and Silver City road. The lead is probably the strongest in the district with a stream affording 10,000 acre feet per annum about 1000 yds. from and 600 ft. below the claims and running parallel to them. Cross-cut tunnel driven 150 feet to cut the vein, leaving 200 ft. still to be driven, depth from the surface when completed, about 225 ft. Mill runs from adjoining property yielded in excess of $25 per ton. Good quarters and blacksmith shop and equipment necessary to prosecute further development on hand. This is a first-class developing proposition and the right party who means business, can get liberal terms which means the long end. Address H. J. Evans, Mogollon, New Mexico.

FOR SALE
**SILVER MINING PROPERTY**

In Austin, Nevada, consisting of approximately 1200 acres, over half of which are patented. Last owned by Austin-Manhattan Consolidated Mining Co. Includes old mines of the MANHATTAN SILVER MINING CO., with record production of over TWENTY MILLION DOLLARS. None of the old mines are deep.

**WM. A. MARSHALL**
Resident Agent Austin, Nevada

**A Canadian Manufacturer of Machinery**

For the use of contractors, etc., is open to undertake the manufacture of any other machinery or device for the use of either contractors or miners, and invites correspondence with holders of Canadian patents, or with U. S. concerns desiring a Canadian manufacturing agency. Liberal inducements also offered for successful suggestions regarding machinery or other articles that can be manufactured and sold in connection with the above-mentioned lines. Address BO-558, Eng. & Min. Journal.

**New Patented Process for Smelting**

Of manganese and iron ores. Correspondence invited with parties who can finance experimental work on new process for production of ferro-manganese, pig iron, and ferro-silicon. This is not an electric furnace process. BO-563, Eng. & Min. Journal, Rialto Bldg., San Francisco.

## ERNEST STEIN

**Specializing Flotation, Ore Testing, Working out best method of Ore Treatment. Mill Designs.**

P. O. 79, Durango, Mexico.

Keep Your Eye on the Searchlight Section and your Ad in it

# RAILS WIRE

FOR SALE
FOR IMMEDIATE SHIPMENT

## MATERIAL *and* EQUIPMENT

OF THE

## FRIENDLY *and* SISTERSVILLE RAILWAY CO.

SISTERSVILLE, W. VA.

The material is in excellent condition, consisting of 70 lb. A. S. C. E. Steel Rails, Ties, Steel Bridges, Copper Feed and Trolley Wire, I-Beams, Bridge Timbers, Poles, Brackets, Etc., Etc.

We also offer a Large Tonnage New and Relaying Rails located in our various yards.

**THE WILKOFF COMPANY**
FIRST NATIONAL BANK BLDG., PITTSBURGH, PA.
WOOLWORTH BLDG., NEW YORK CITY

---

*WANTED AT ONCE*

Four to five hundred feet

## BELT CONVEYOR

for handling sand; capacity 60 tons per hour; new or second-hand. State full particulars.

**PIEL CONSTRUCTION CO., 2546 Edmondson Ave., Baltimore, Md.**

---

## EQUIPMENT FOR SALE

**LOCOMOTIVES**

1 Bell 6-ton, std. gauge.
1—Bell 4-ton, 24-in. gauge.
1—Vulcan 35-ton, 4-wheel, 0-4-0 std. gauge, No. 2104.

**CARS**

12—13-cu.yd. air dump, std. gauge, full M.B.C.
10—4-cu.yd. Continental 2-way dump, 36-in. gauge.
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5—Lidgerwood Builders Hod Hoists, drums 30-in. dia. x 24-in. face x 4-in. flange, dir. geared to 52-H.P. Westinghouse variable speed motors, 220-volt, direct current.
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2—Meade-Morrison, single drum, drum 30-in. dia. x 24-in. face x 3-in. flange, geared to 40-H.P. Westinghouse 500-volt, D.C. motor.

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2—8¼-in. x 10 in. Flory double drum hoists, drums 27 in. dia. x 30 in. face, steam inlet 1½-in., outlet 2-in.
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Can also furnish tanks for Thickeners.

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3—Agitators for 14-ft. Diameter Tanks.

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All are equipped with magneto and circulating pump. Practically new. Immediate shipment from Deming, New Mexico.

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***1000 Other Machinery Bargains.***

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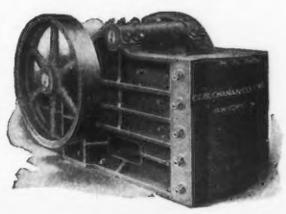

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All the rotary kilns for burning the magnesite were operated with **The Holbeck Pulverized Coal System,** which effected a large increase in capacity over the fuel formerly used.

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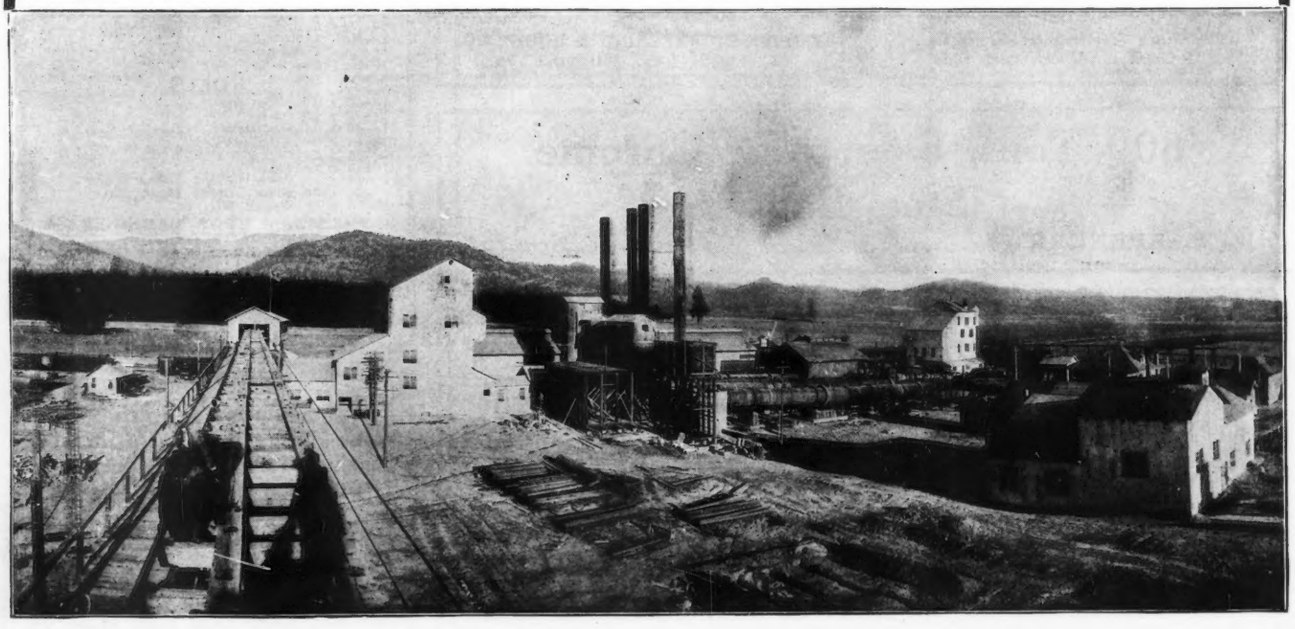

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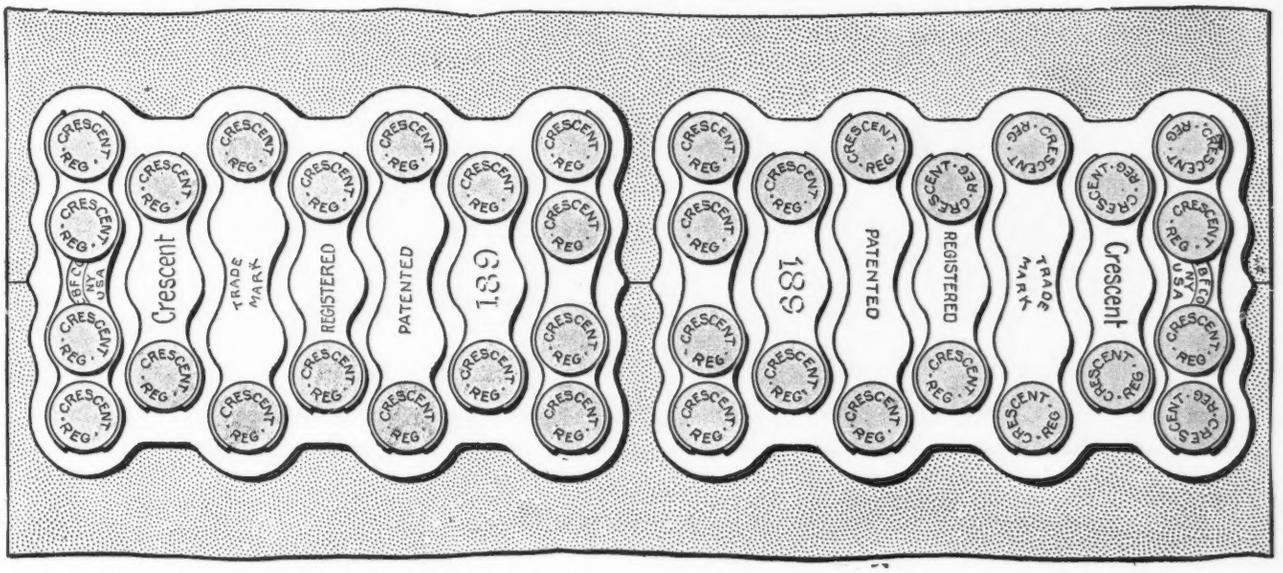


To have your belts hug the pulleys with a continuous, uniform, gripping surface means power economy and increased production.

You can make your belts endless on the pulley side with an even, tight, perfectly flush, butt joint which never loosens by using Crescent Belt Fasteners. And, a Crescent joint fits the pulley snugly and tightly—it's the belt itself.

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Cross section of Belt joint, joined to stay with Crescent Plates and Crescent Rivets.

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Belts joined by the Crescent method can be shortened in less time with less expense and are more efficiently rejoined than by any other method.

Interesting "Booklet S" is full of meaty information on better belt service.

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***Branches:*** **Birmingham, England—Toronto, Canada**

***Distributors throughout the World***

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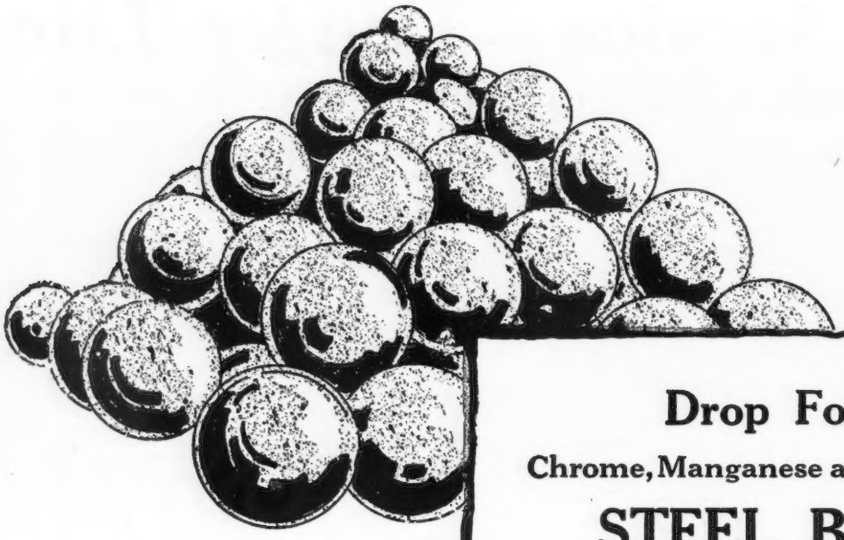
## *"For Continuous Production"*

***on power transmission, elevating and conveying belting of every make, length, width and thickness.***



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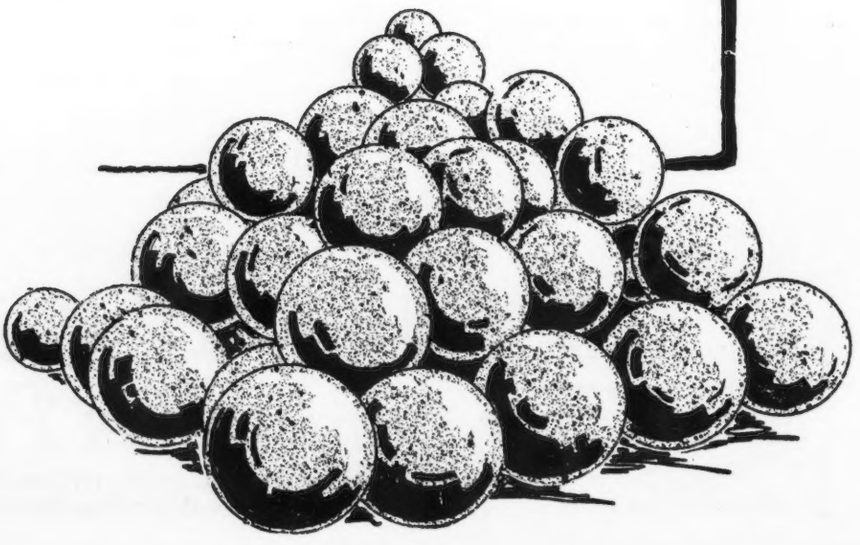

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**TRACTORS** REG. U.S. PAT. OFF.

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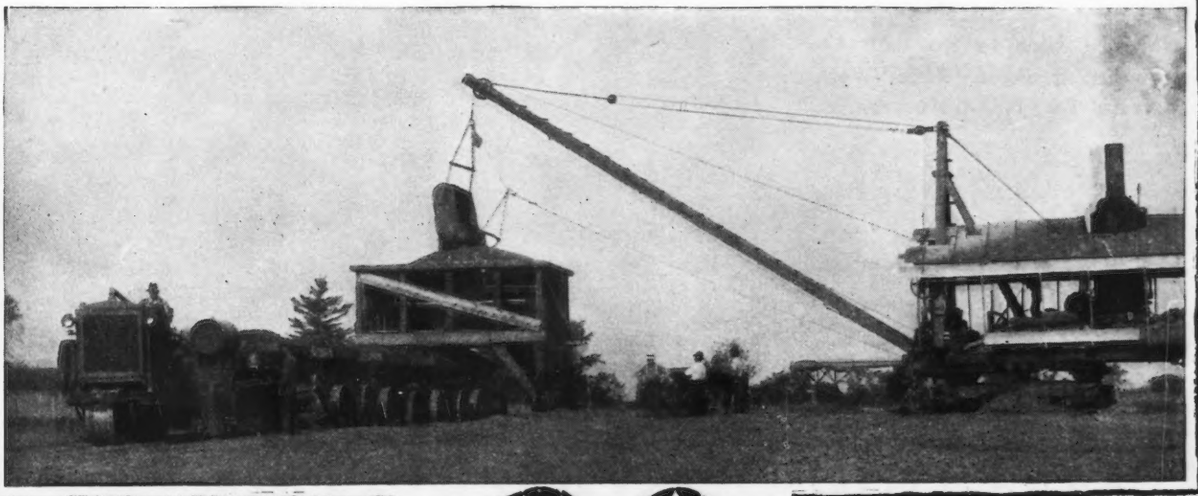

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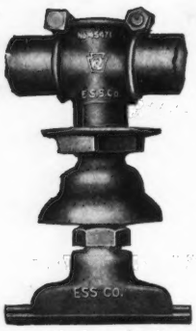
For attaching suspensions to steel I-beams.



For vertical or horizontal pipe construction.

For vertical or horizontal pipe construction.

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# Trolley Wire Suspensions

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In Keystone Overhead Trolley Material you get something new in mining and business experience—"Overhead" that's an Asset—and there's a reason for it. Keystone line suspensions are designed and manufactured for a special service and every detail of their construction has been worked out with a view to permanent utility in unfavorable conditions.

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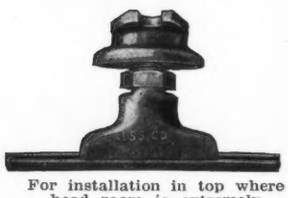
**We would like to go into this matter in greater detail—why not write for full information?**

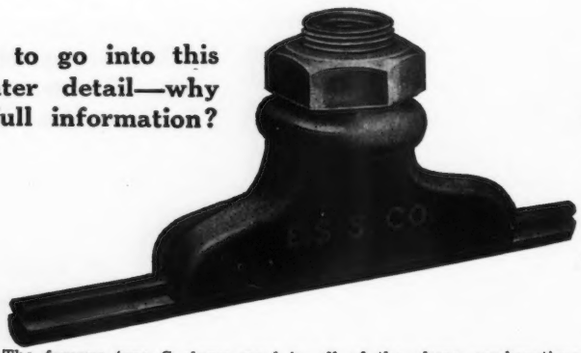
For installation in timber.

For installation in top.



For installation in top where head room is extremely limited.

For horizontal pipe construction.



The famous type C clamp used in all of the above combinations. Well known for its great strength, ease of installation and dependency. It consists of but three parts—two malleable iron clamping jaws and one hexagon locking nut.

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***"—That Weird Penetrating Sound Reaches for Miles Around."***

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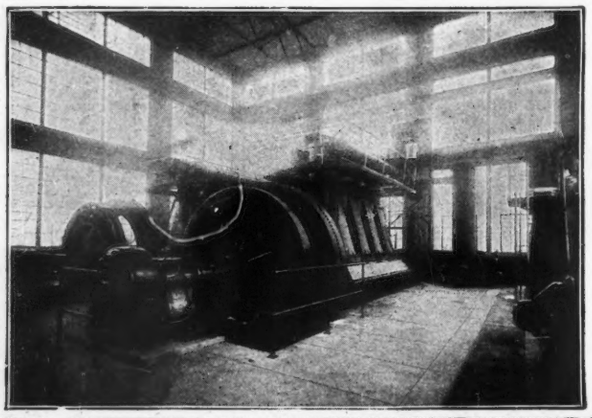

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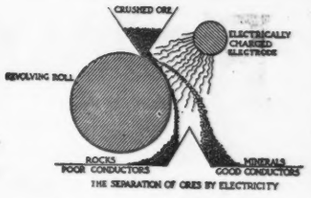

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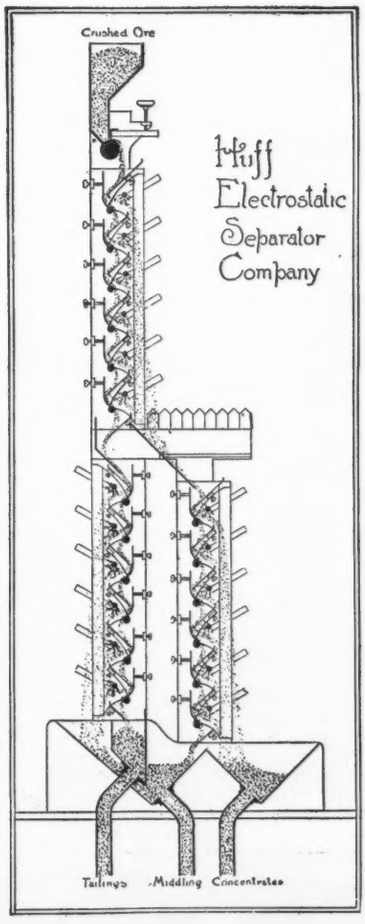


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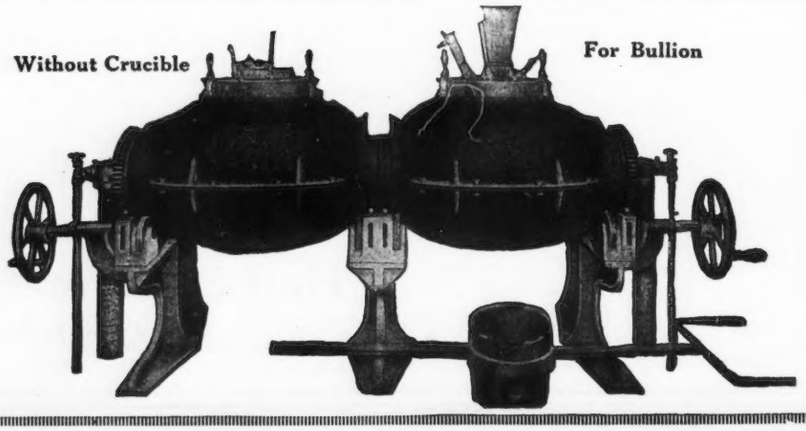
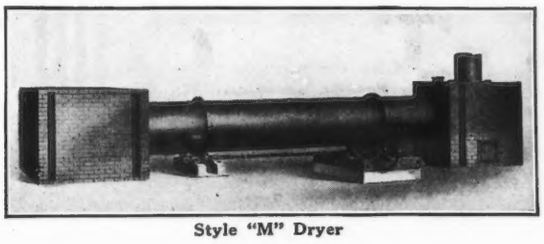
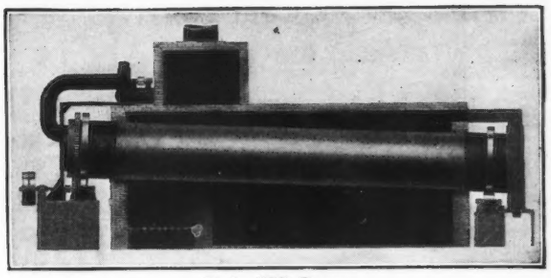




Style "M" Dryer



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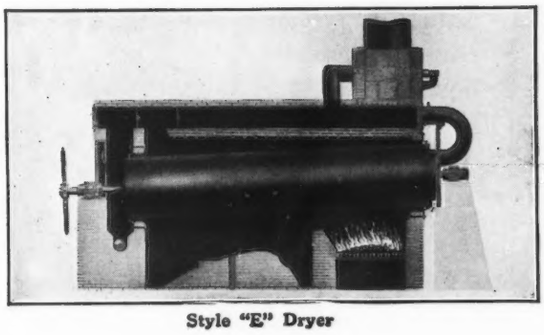

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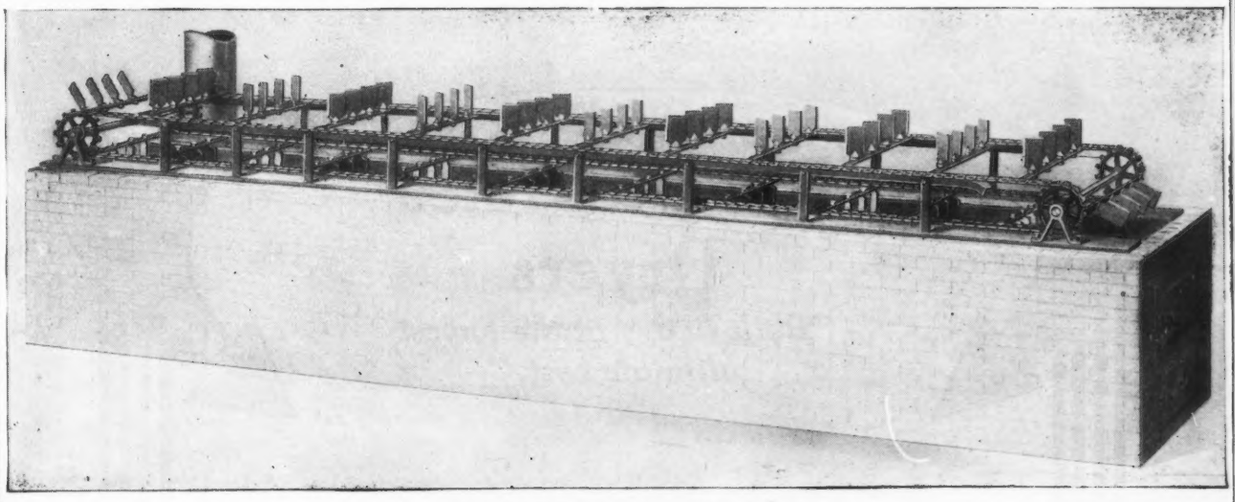

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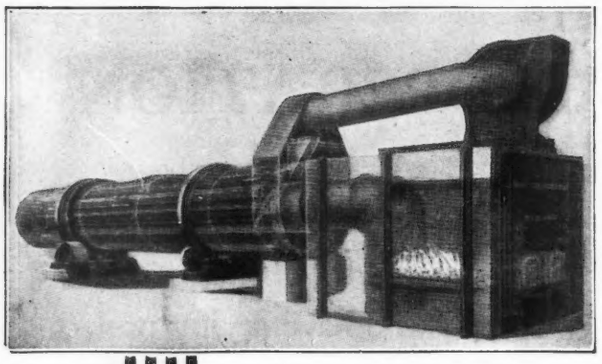

Phantom view of
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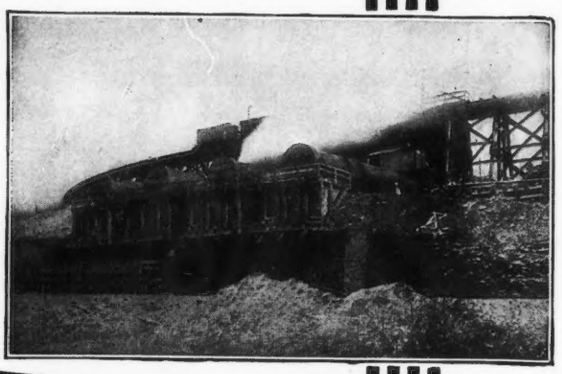

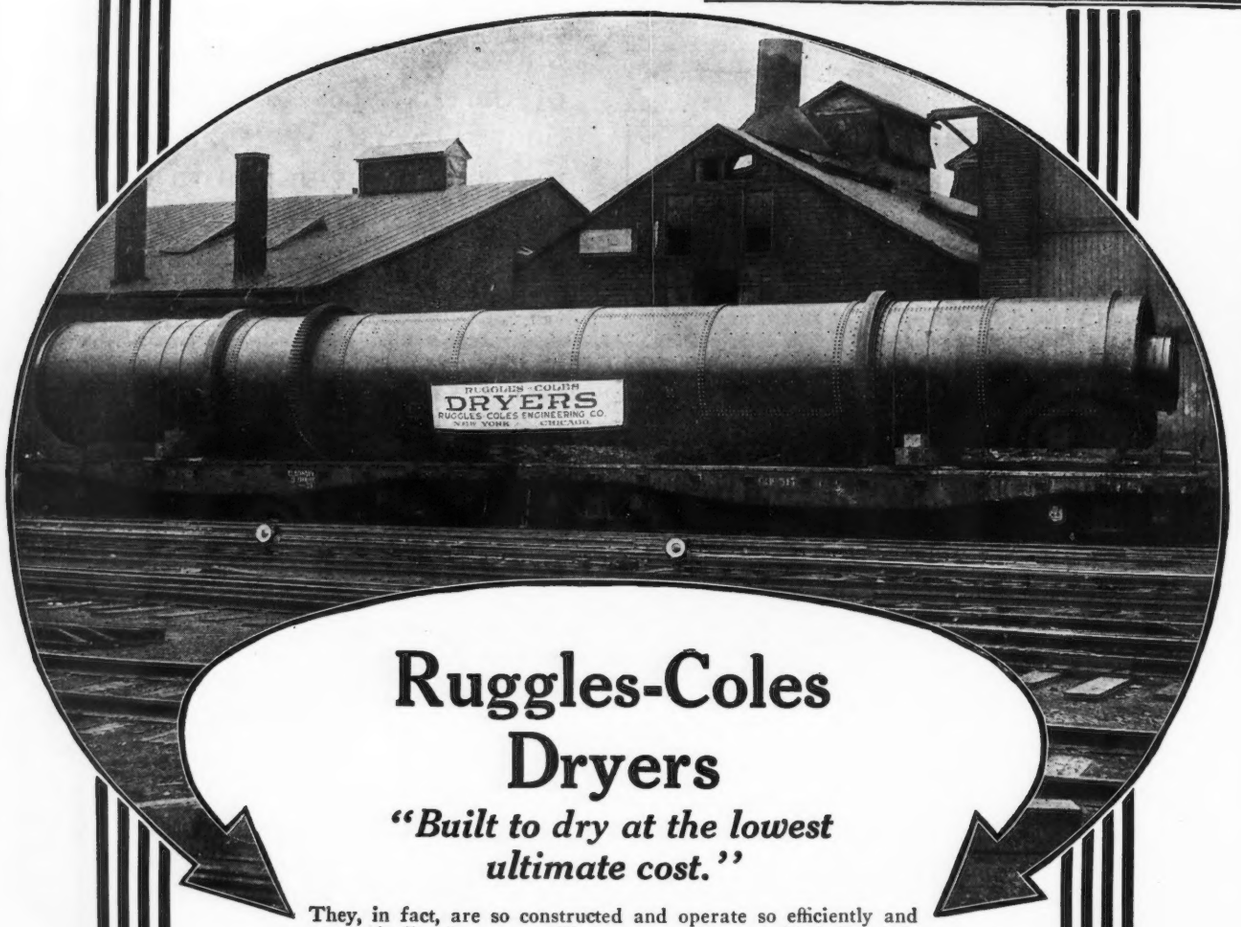


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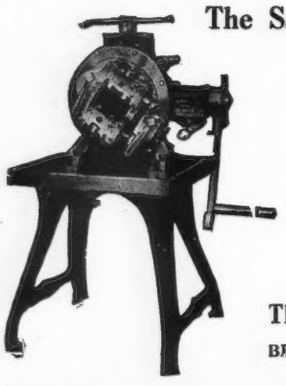

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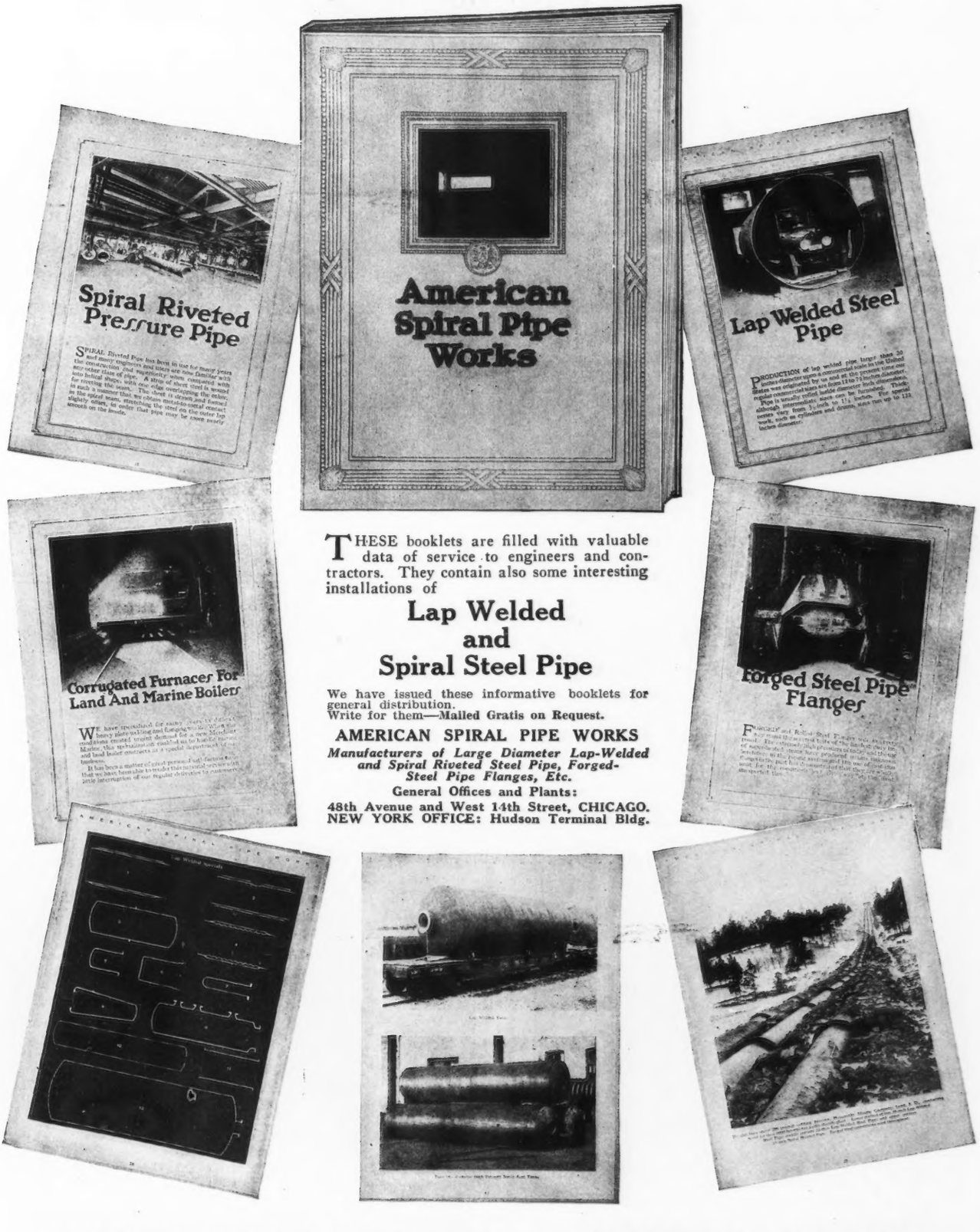
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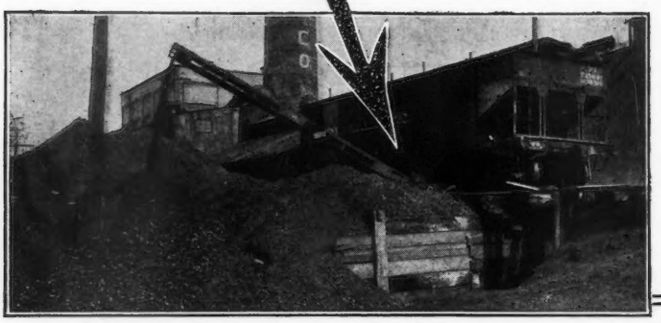

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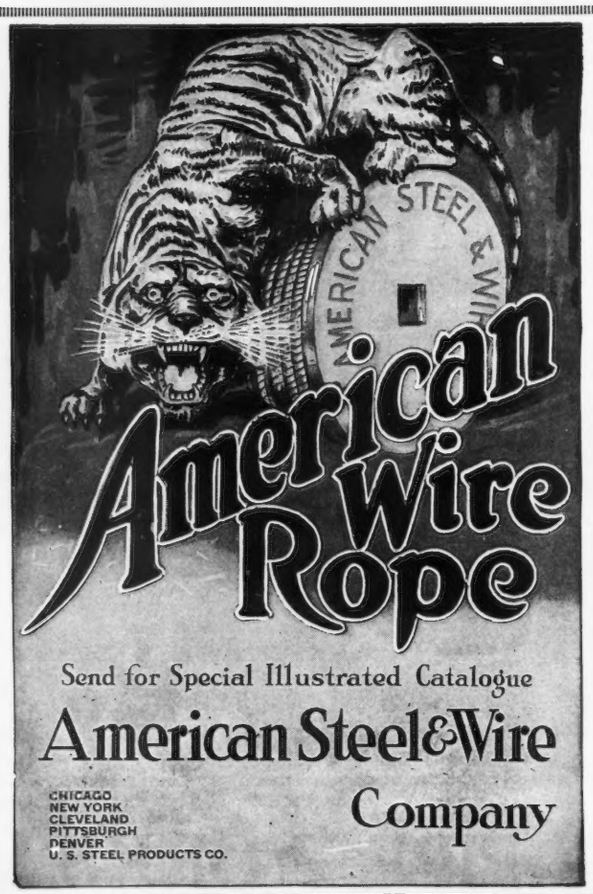


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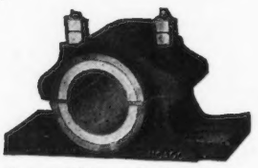

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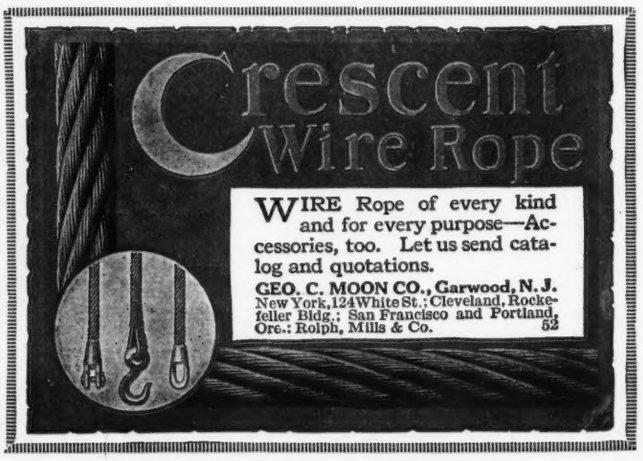


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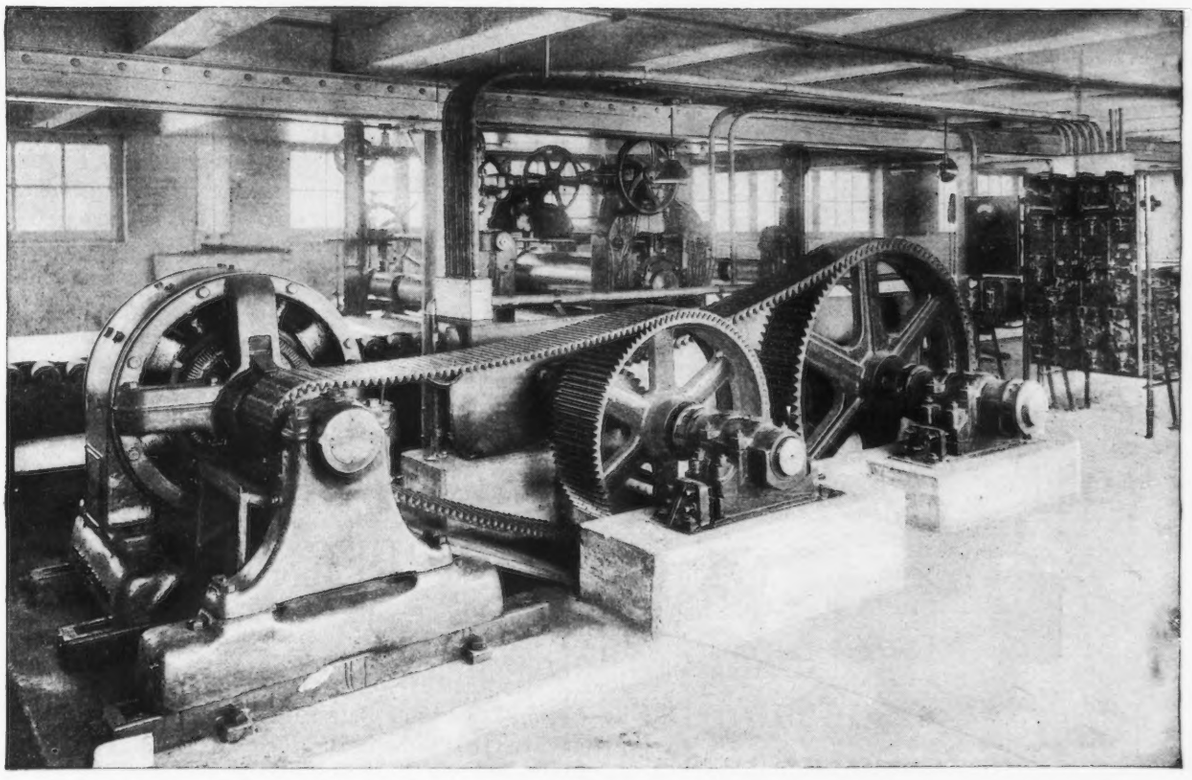

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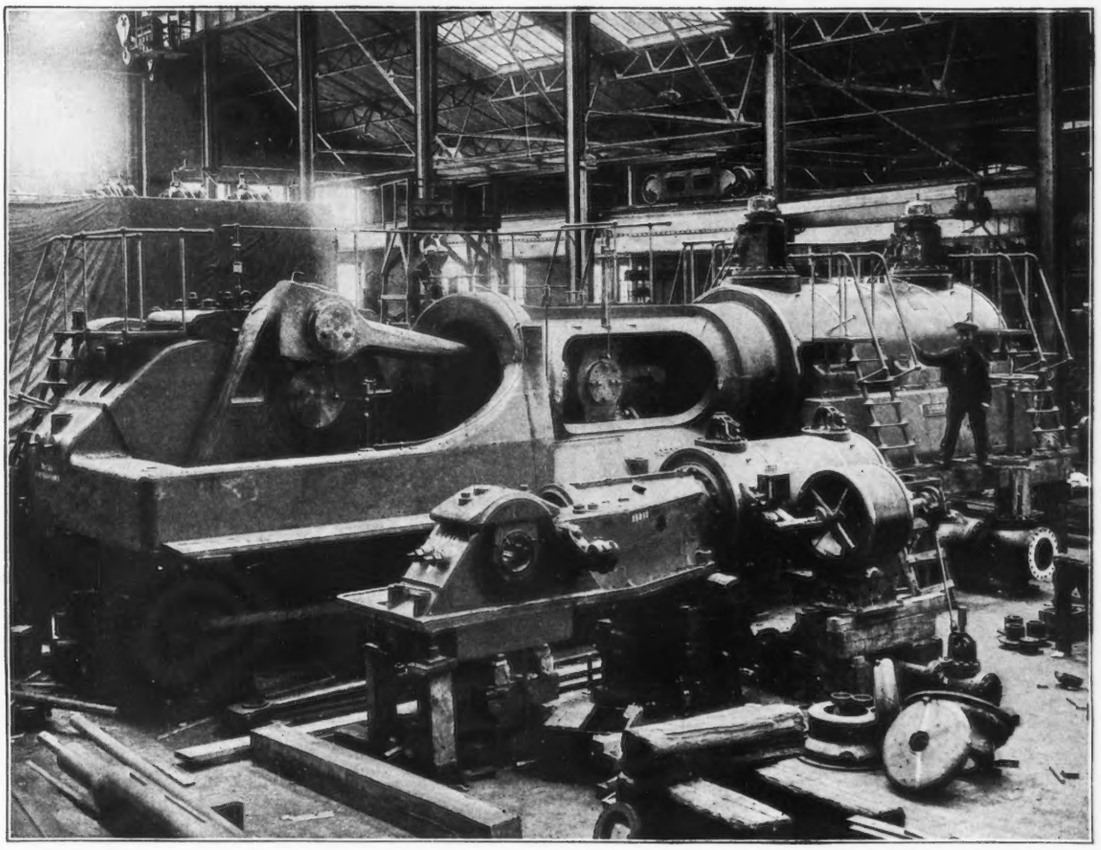

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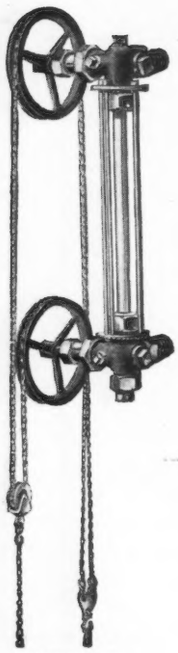

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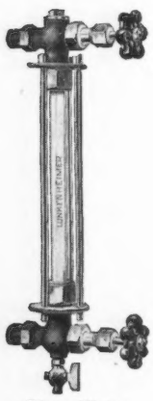

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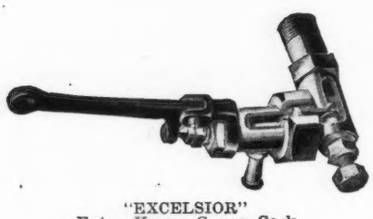

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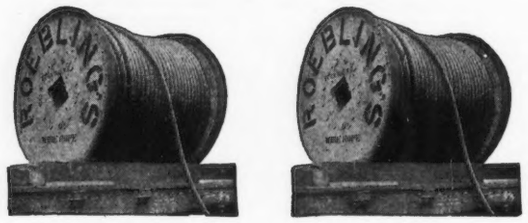


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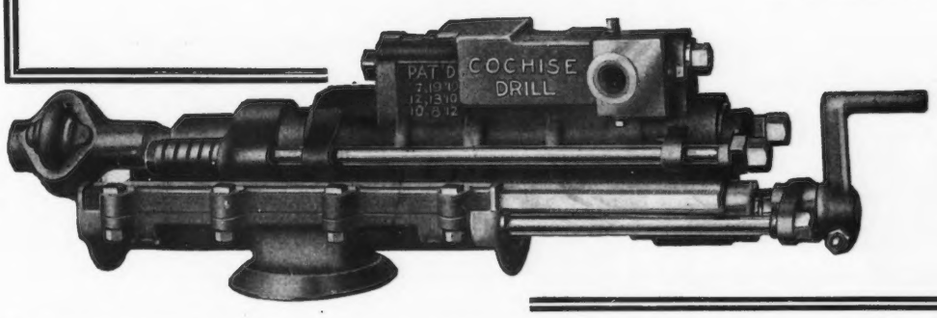
CONSOLIDATED STEEL CORPORATION, 165 Broadway, New York, is the sole exporter of our commercial products. Address all export inquiries to them.

## We'll Prove In a Demonstration That Cochise Drills Will

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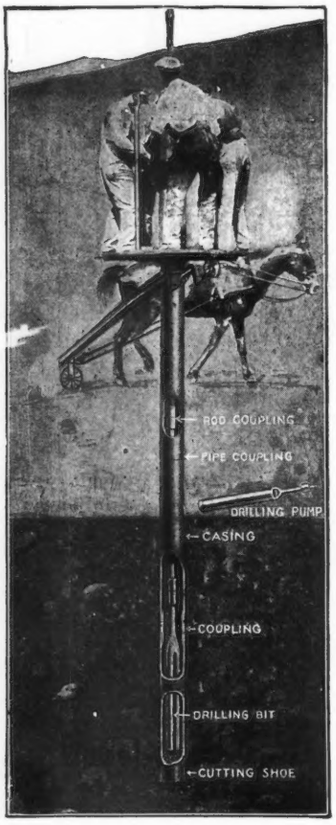


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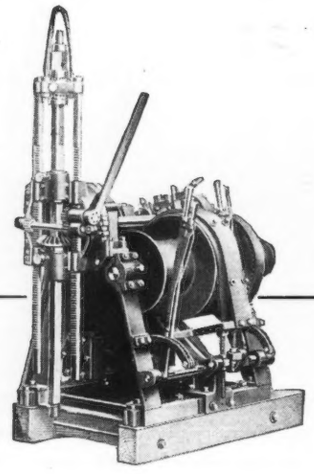

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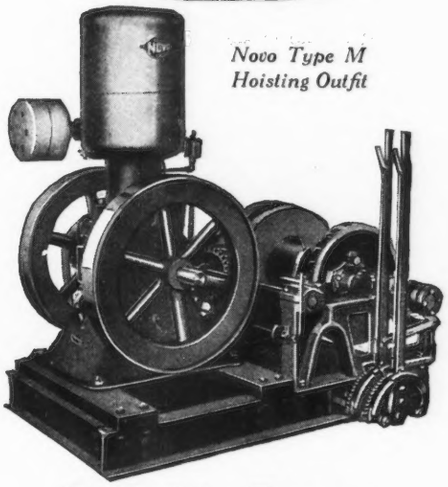

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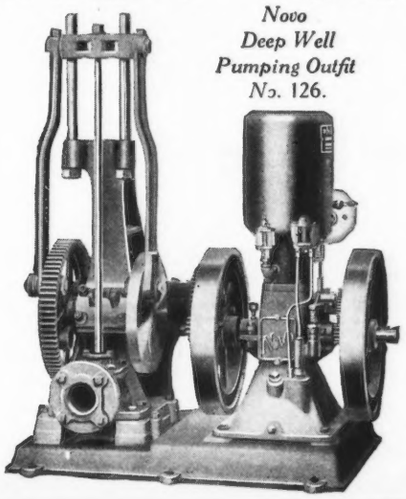

*Novo Deep Well Pumping Outfit No. 126.*



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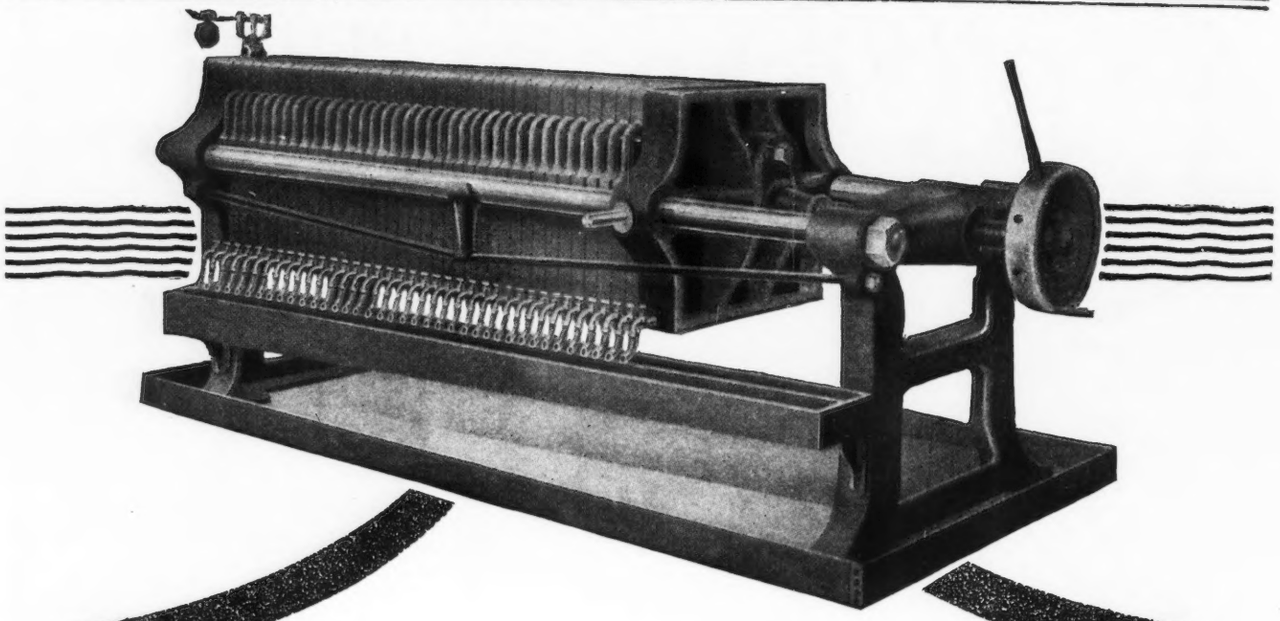

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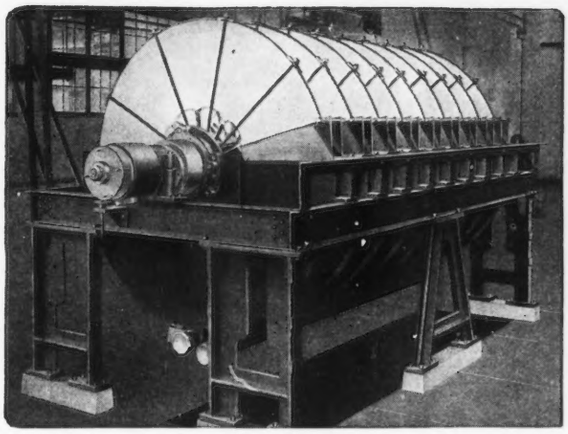

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Cake Discharge on Large American Filter

## *READ BELOW HOW THE AMERICAN FILTER IS SELLING ITSELF:*

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VERTICAL AND HORIZONTAL DESIGNS

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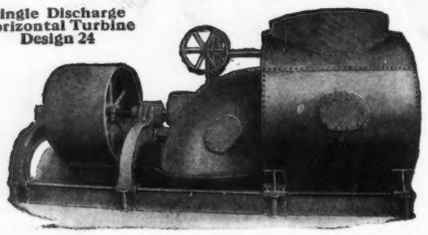

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THE JAMES LEFFEL & COMPANY, Springfield, Ohio, U. S. A.

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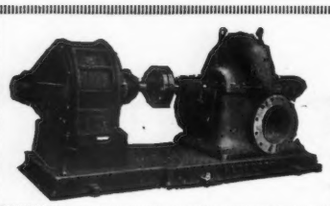

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Especially designed for the economical and dependable delivery of air between ½ and 10 lbs. per sq. inch pressure for pulverized coal installations, flotation plants, smelter, cupola and furnace work. We are also prepared to quote on cyanide pumps. **Let us send literature.**

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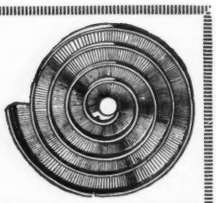

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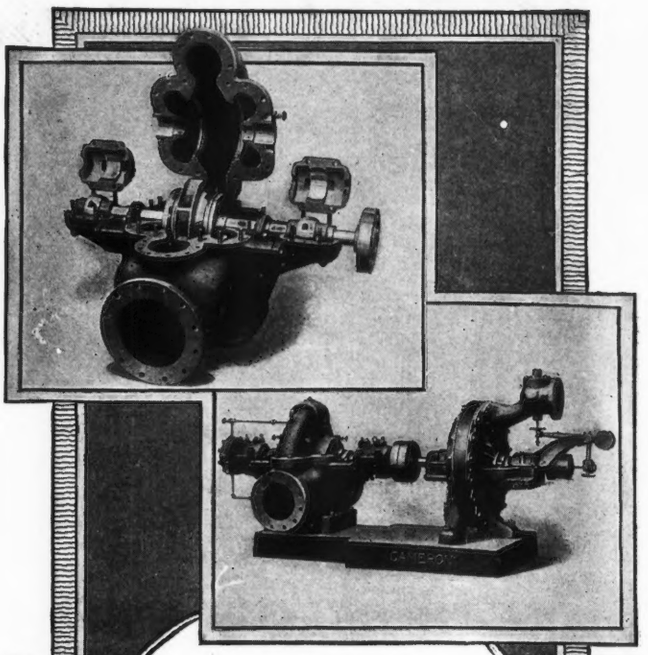

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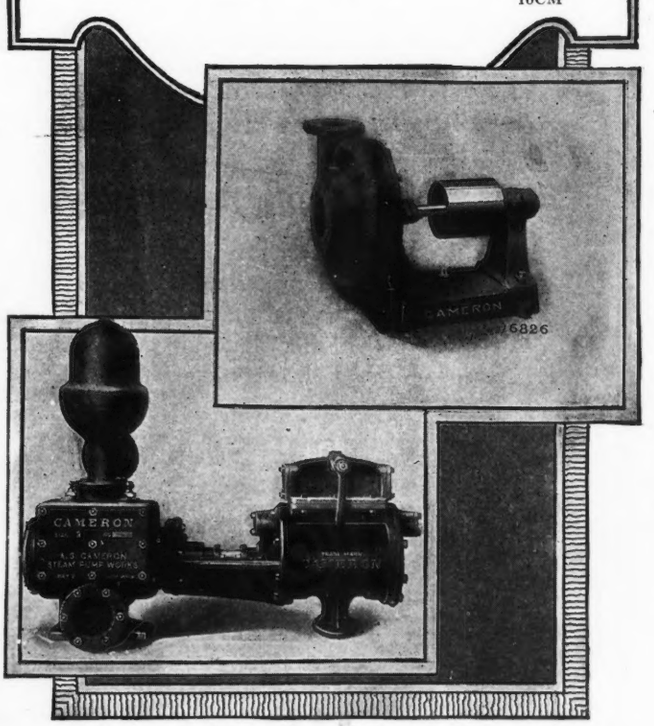
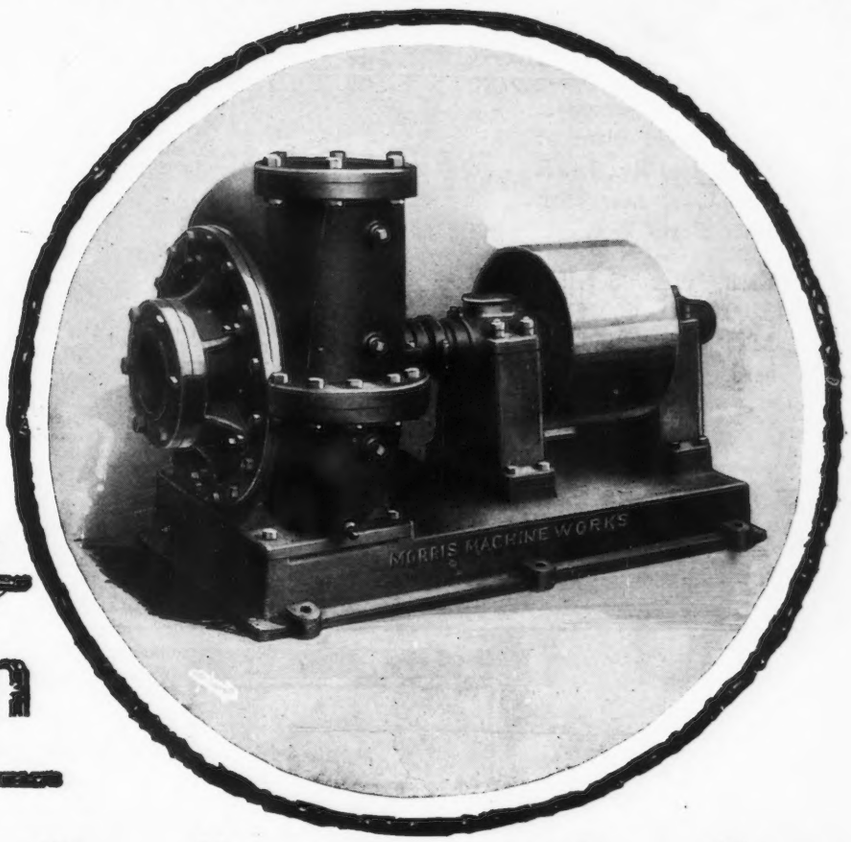


# MORRIS

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Such are Morris Centrifugals for service where acidulous water or grit will eat out or wear out the "innards" of any ordinary pump in a brief period. For such service we will give you practically an *independent pump* of manganese steel or 30% semi-steel mixture, extra heavy at the points of wear, *inclosed in a cast-iron casing.* There are no bolts or screw holes in this "lining"—the protection is *complete.* By removing the upper half of the pump shell you can lift it out readily. Everything else about this type of pump is constructed equally well—the shaft, the bearings, the stuffing box. Of course the "first cost" is high—but its *ultimate* economy, its *durability* more than justify the worth of the MORRIS *reputation.*

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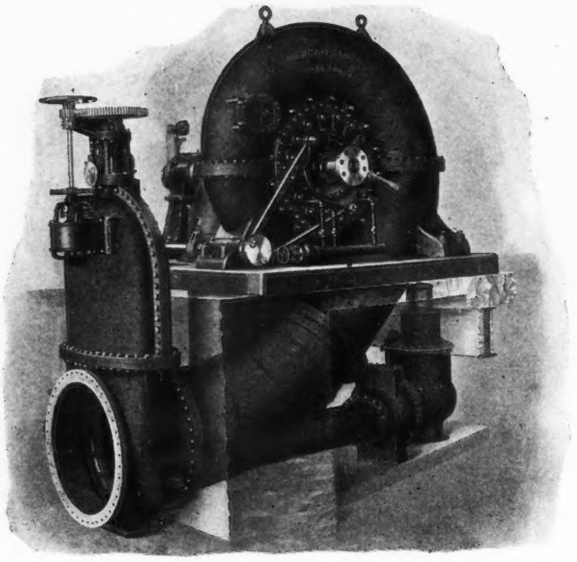
Each unit develops 3200 H.P. 400 R.P. M., under 150-feet head.



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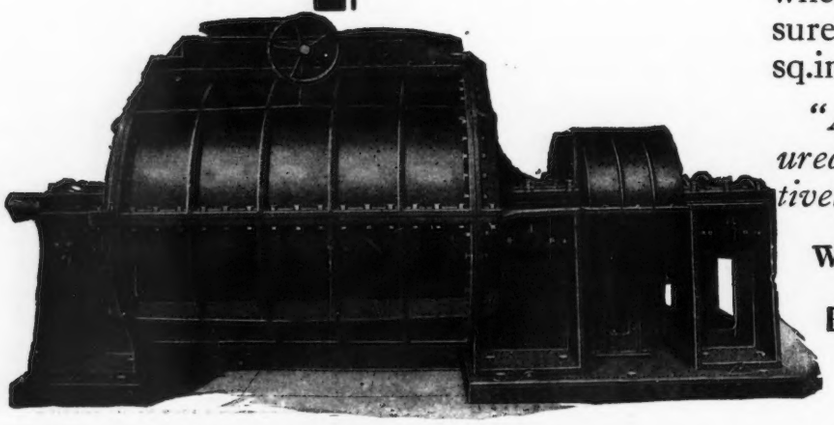

ROOTS Rotary Blowers have an enviable record of efficiency and dependability wherever air is used at pressures of 8 ozs. to 10 lbs. per sq.in.

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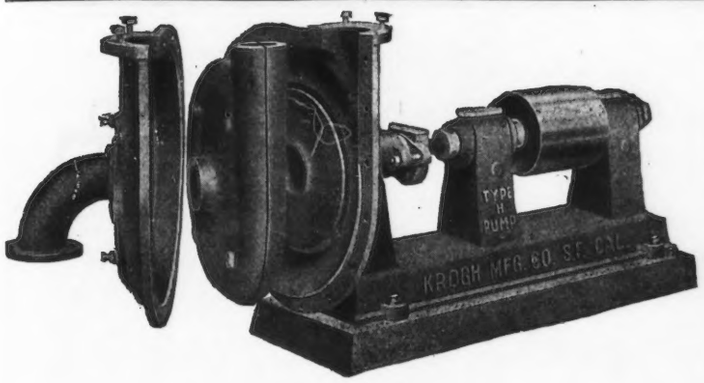


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## because we've something well worth crowing about

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**Arizona Copper has 6 Kroghs**
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**—and look at this partial list of other users—**

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are notable for long life, high efficiency and low cost of replacement.

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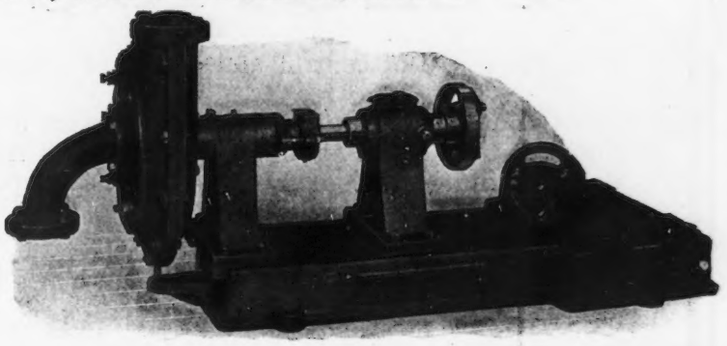

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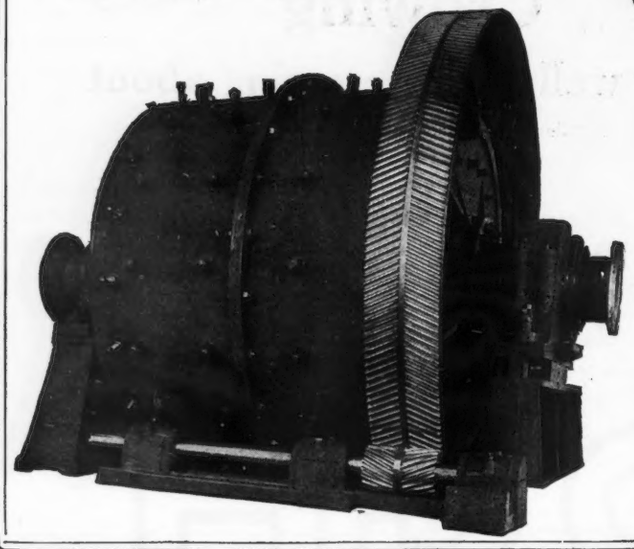

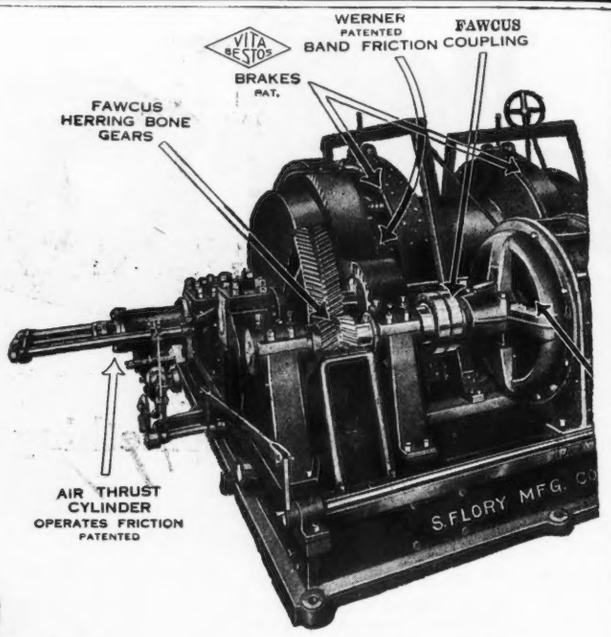


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Complete Enclosed Self-Oiling Transmissions

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We have now resumed the manufacture of our standard line of mining machinery and are prepared to make prompt shipment of your orders.

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for safety, ease of control and length of efficient service.

Dillon-Box Hoists in the larger sizes are all equipped with Herringbone Gears hobbed from solid blanks—made in sizes from 3 to 500 H.P.—single or double drum—A.C. or D.C. drive—any rope speed. Write for details.

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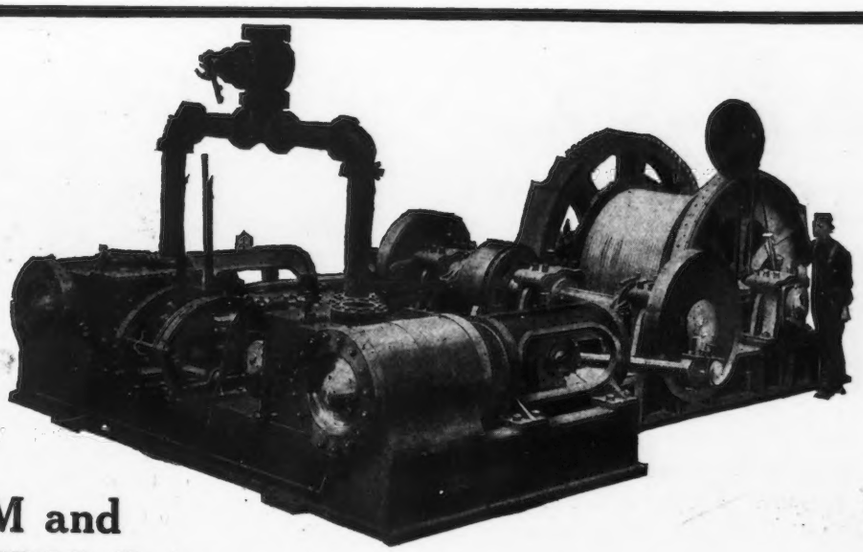

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## For Every Type of Mine Service

It is not one special feature but it is every detail, from bottom of bedplate to top of brake band, that shows in its design and construction the skill and care that insure strength, with speed and economy in operation of the complete hoist.

It is this perfection in detail combined with properly designed hoists that has built and sustained the Lidgerwood reputation.

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Steam hoists up to 1000-hp. Electric hoists in any size.

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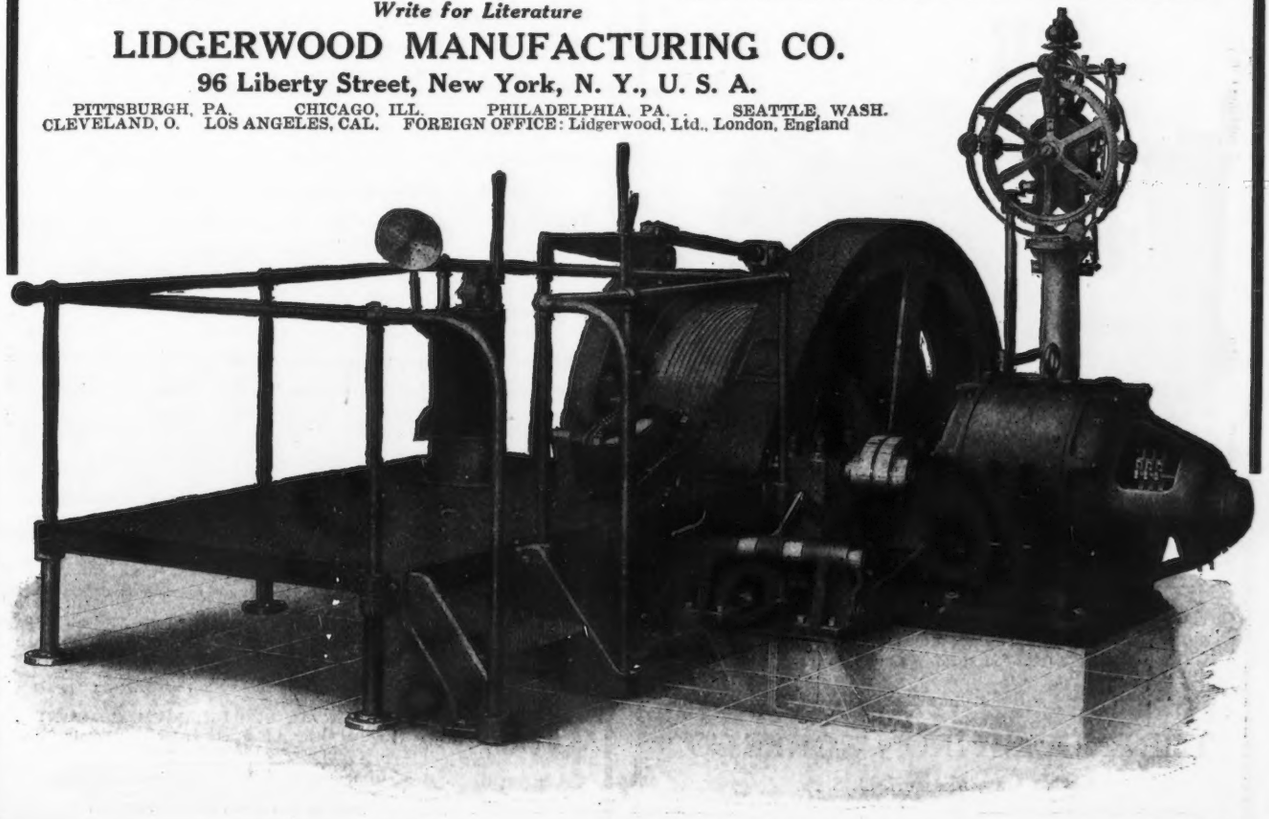
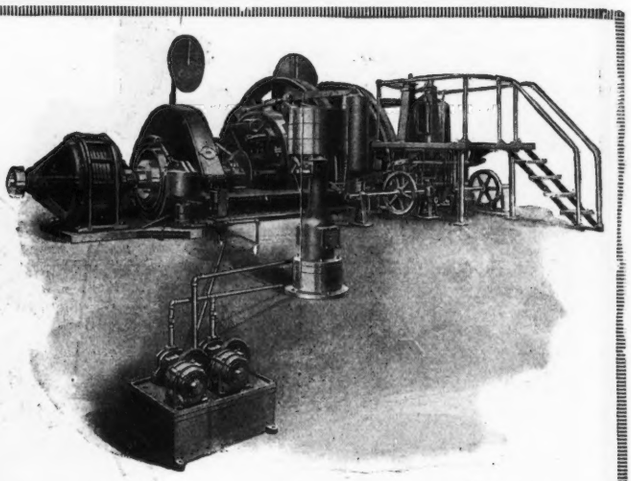


The photograph shows a large

## Ottumwa Electric Hoist

built for the

**Eagle & Blue Bell Mining Co.**
Salt Lake City, Utah



The reels are 12 ft. in diameter and hold 2500 ft. of flat rope. Each reel is driven with axial plate clutch operated by thrust cylinder by means of oil under pressure. The brakes are of the post type gravity applied and released by oil acting in thrust cylinder. The brakes are interlocked with the clutches and so arranged that the clutch can not be thrown out only when the brake is set and the clutch is thrown in before the brake can be released. The gears are run in oil-tight gear case. The hoist is equipped with overwinding device which will apply the emergency brakes in case of overwind, overspeed or failure of current supply to the hoist.

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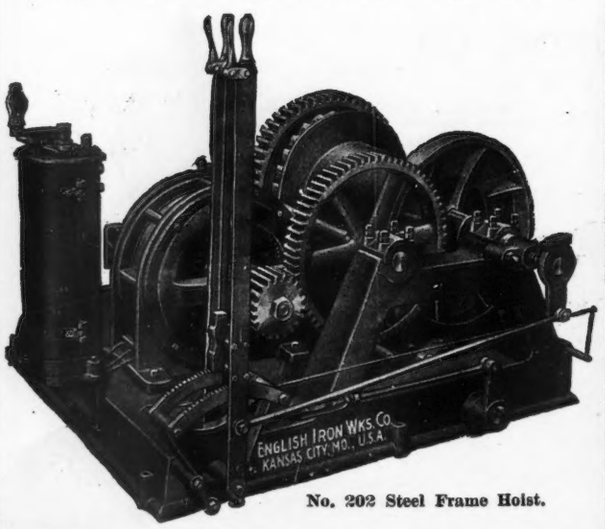


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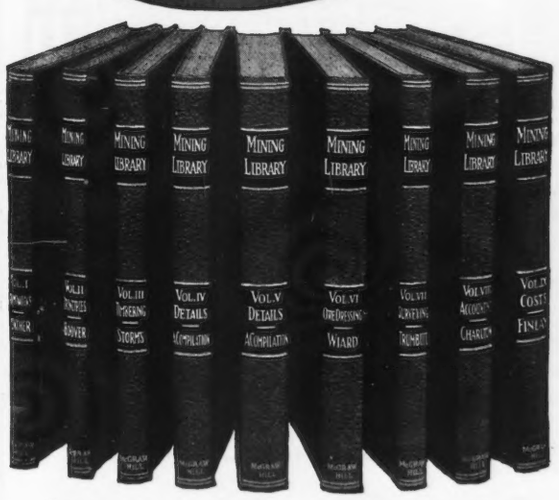


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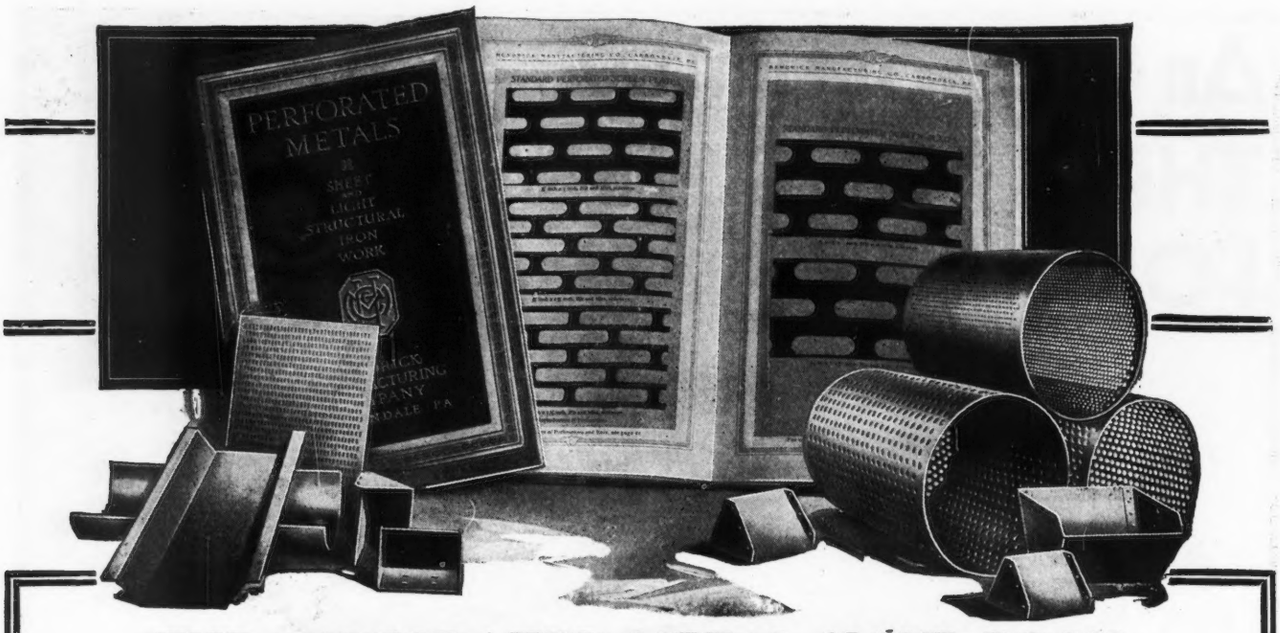


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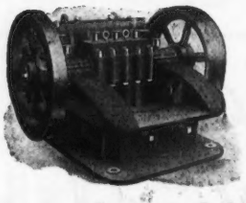

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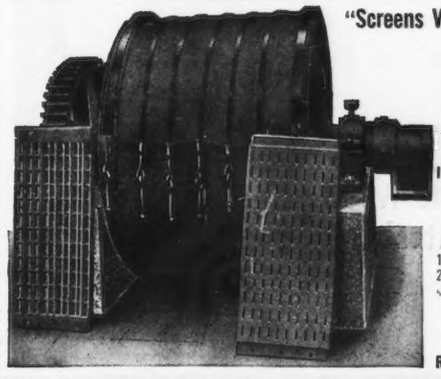

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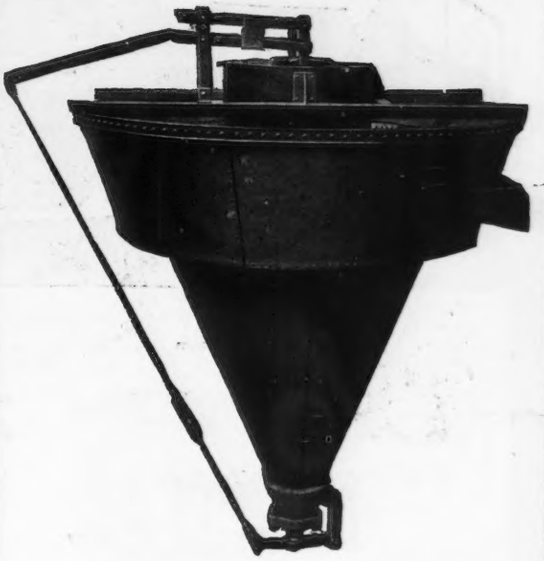

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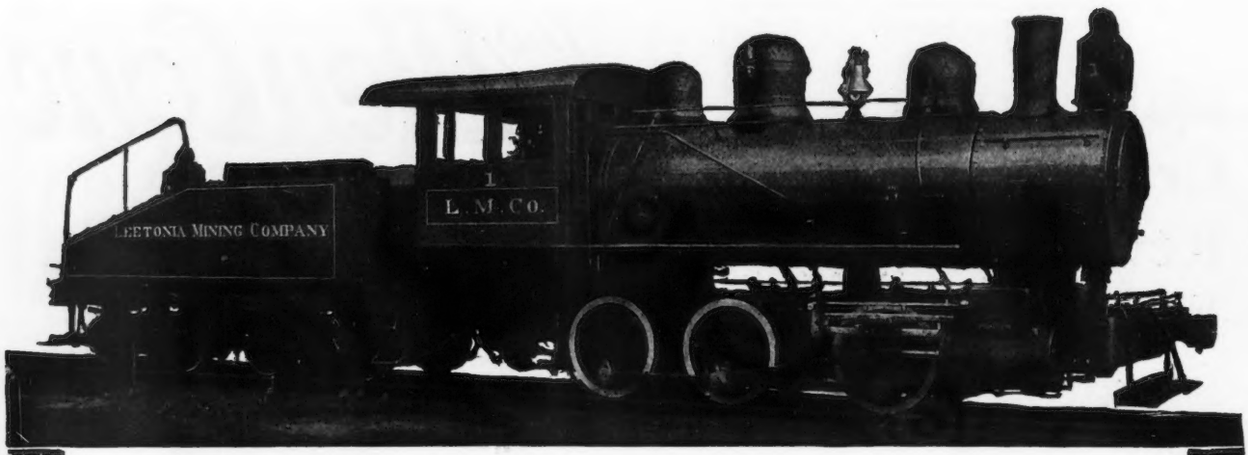


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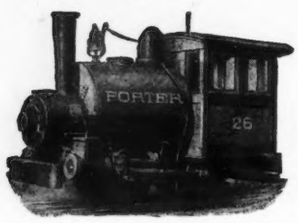


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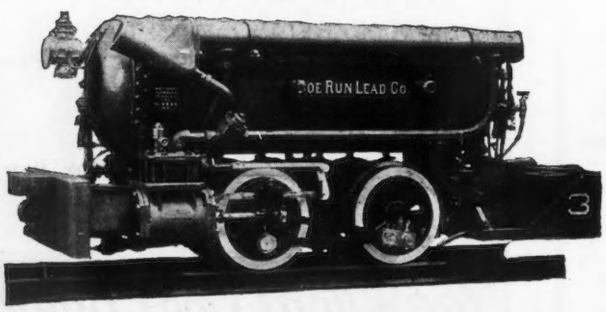


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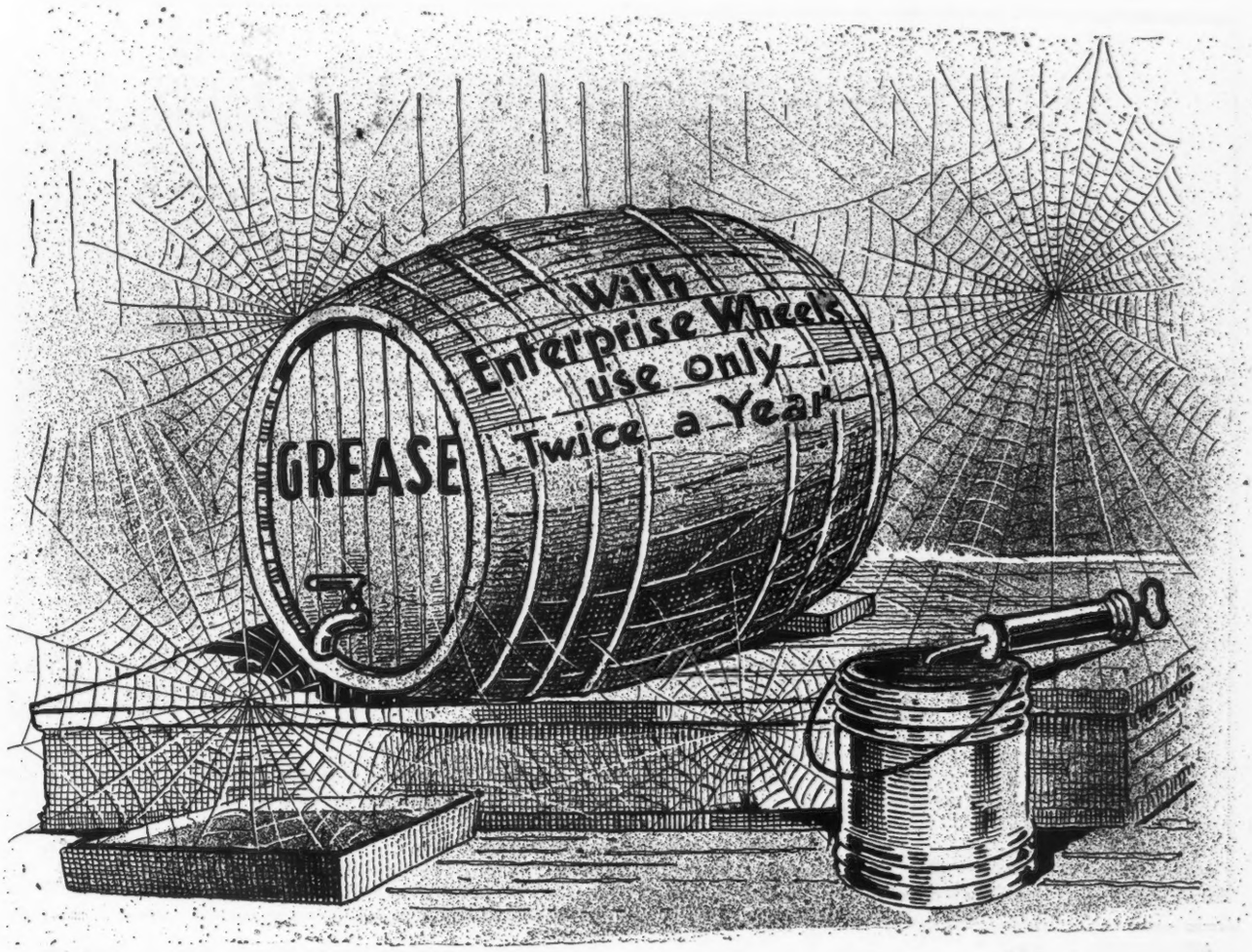


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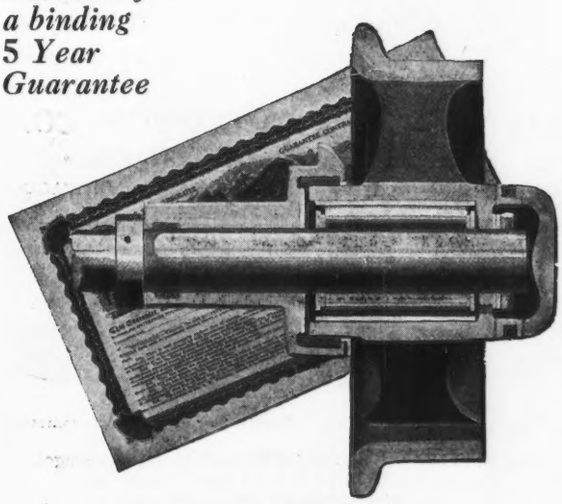

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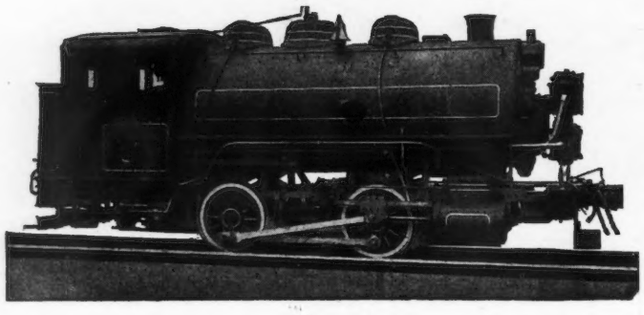

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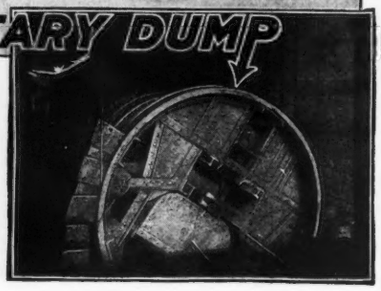

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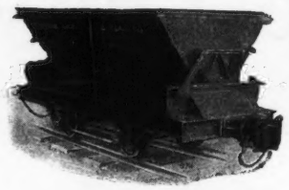

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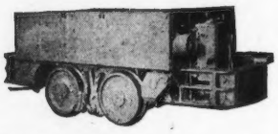

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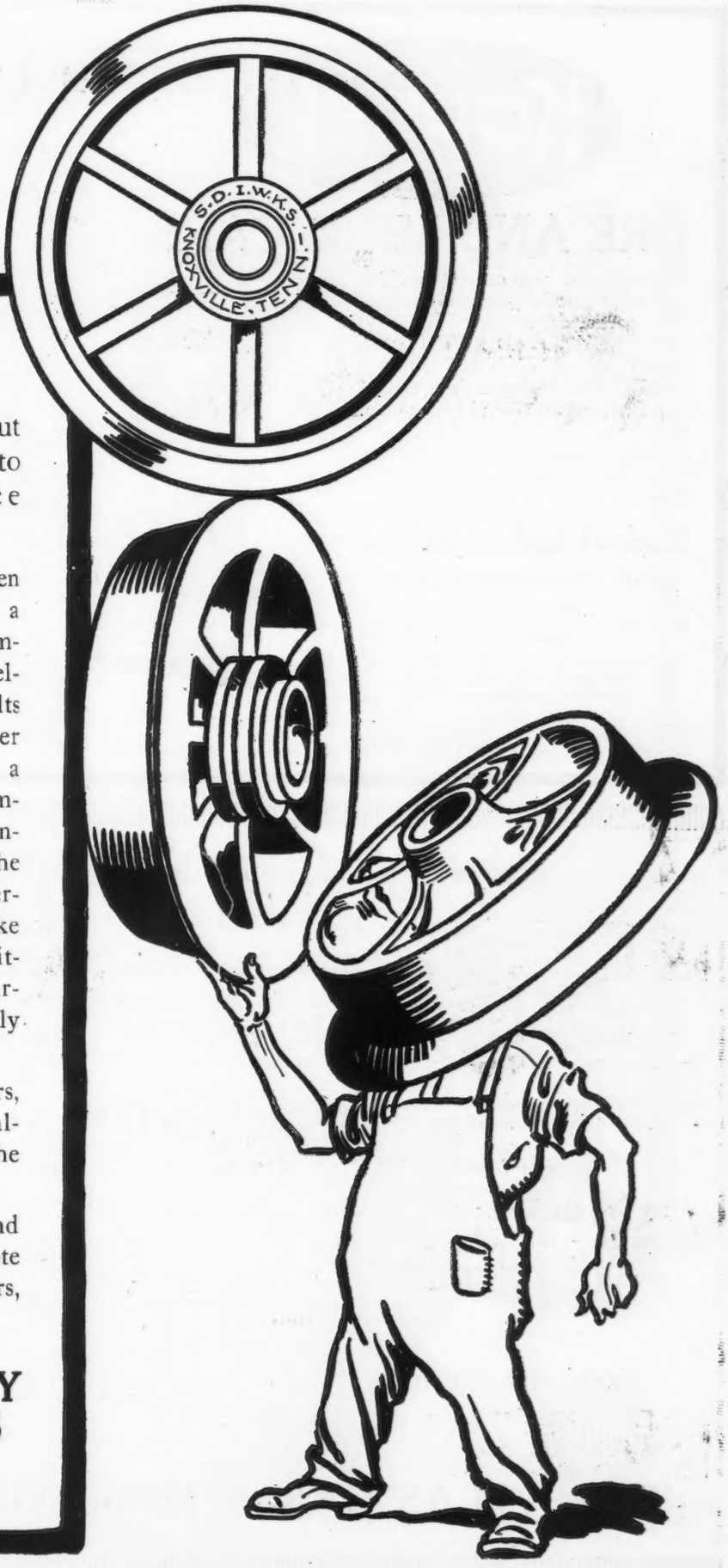


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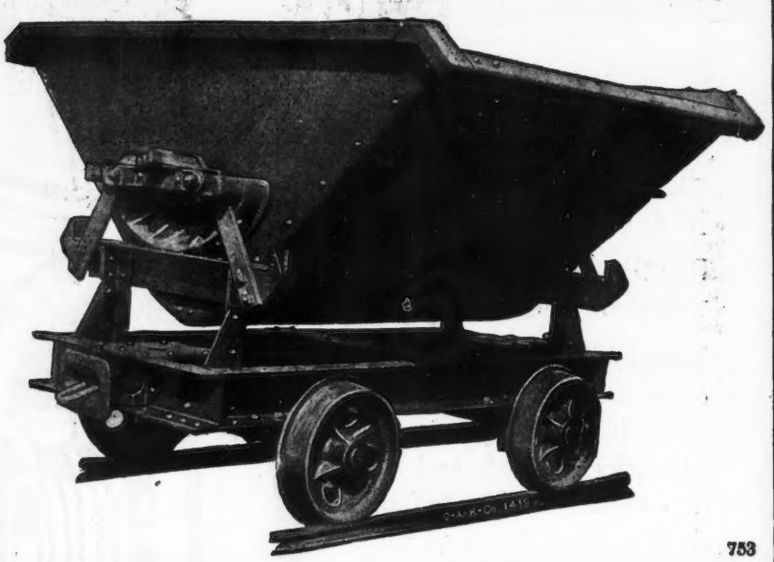

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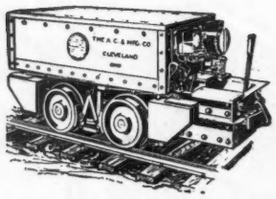

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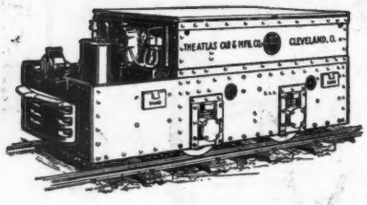

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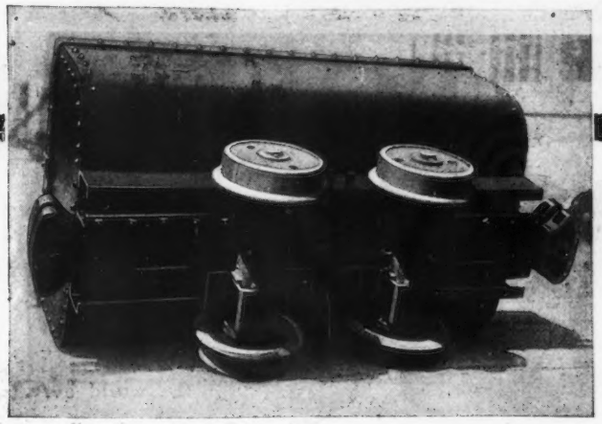

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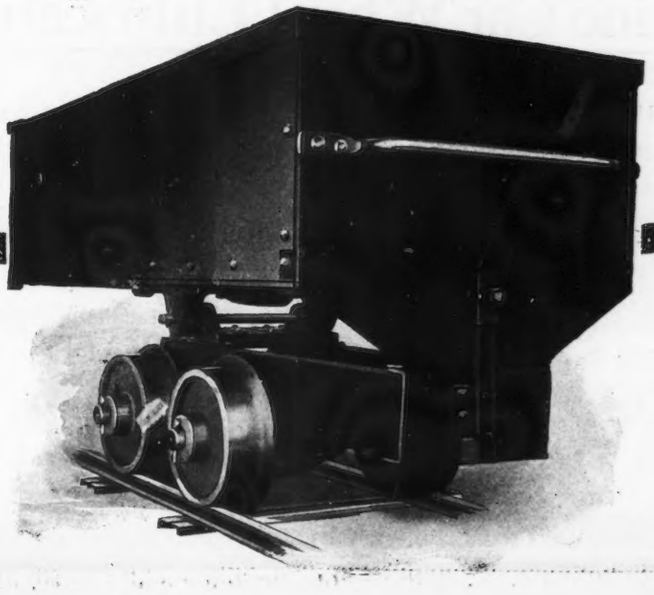

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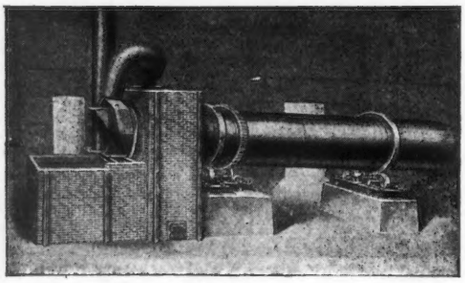

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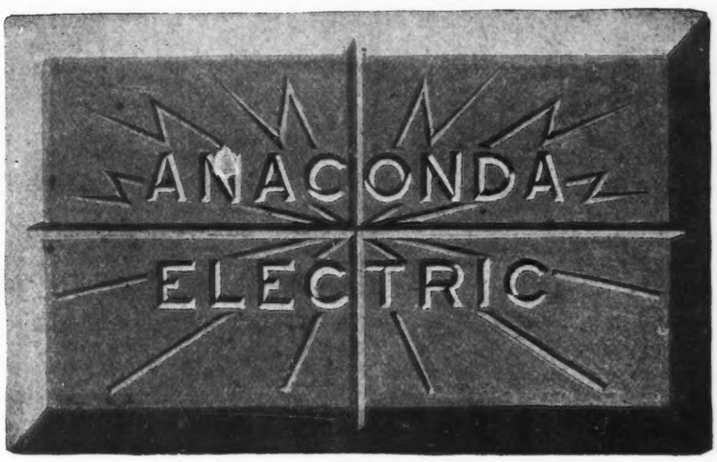


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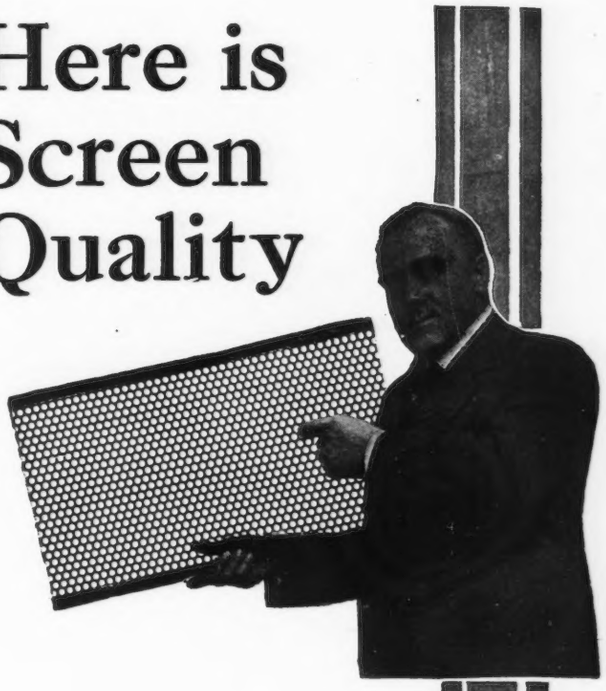

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Colorado Iron Works Co.
Christie Co., L. R.
Kennedy-Van Saun Eng. & Mfg. Corp.
Morse Bros. Mach. & Supply Co.
Ruggles-Coles Eng. Co.
Traylor Engineering & Mfg. Co.
Vulcan Iron Works

**Dryers, Sand and Coal**
American Process Co.
Christie Co., L. R.
Colorado Iron Works Co.
Electric Service Supplies Co.
Ruggles-Coles Engineering Co.
Vulcan Iron Works

**Dumps, Rotary**
Wood Equipment Co.

**Dust Protectors (See "Respirators")**

**Dust Removal from Gas**
Bartlett Hayward Co.

**Dynamite**
Aetna Explosives Co.
Atlas Powder Co.

**Electrical Supplies**
Electric Service Supplies Co.
Hendrie & Bolthoff, M. & S. Co.
Mine & Smelter Supply Co., The

**Elevators, Bucket**
Bartlett & Snow Co., C. O.
Jeffrey Mfg. Co., The
Stephens-Adamson Mfg. Co.
Traylor Engineering & Mfg. Co.

**Emergency Cases**
Ambrine Laboratories

**Employees**
Business Men's Clearing House

**Engineers, Construction**
Thompson-Starrett Co.

**Engines, Gas and Gasoline**
Allis-Chalmers Mfg. Co.
Bartlett Hayward Co.
Chicago Pneumatic Tool Co.
Mine & Smelter Supply Co., The
Morse Bros. Mach. & Supply Co.
Novo Engine Co.

**Engines, Hoisting**
Ottumwa Iron Works Co.

**Engines, Oil**
Allis-Chalmers Mfg. Co.
Chicago Pneumatic Tool Co.
Hendrie & Bolthoff M. & S. Co.
Ingersoll-Rand Co.
McIntosh & Seymour Corp.
Nordberg Mfg. Co.

**Engineering and Contracting**
Fitch, Jr., Walter

**Engineers, Designing and Contracting**
Bradley, Bruff & Labarthe

**Engines, Steam**
Allis-Chalmers Mfg. Co.
Ingersoll-Rand Co.
Morse Bros. Mach. & Supply Co.

**Exhausters**
Connersville Blower Co., The
Morse Bros. Mach. & Supply Co.

**Excavaters, Cableway**
Jeffrey Mfg. Co., The

**Excavators, Dragline**
Jeffrey Mfg. Co., The
Marion Steam Shovel Co.

**Excavating Machinery**
Marion Steam Shovel Co.

**Exploders**
California Cap Co.

**Explosives**
Atlas Powder Co.

**Fans, Ventilating**
Jeffrey Mfg. Co., The
Ottumwa Iron Works Co.

**Feed Water Purifying Apparatus**
Permutit Co.

**Feeders, Ore**
Bartlett & Snow Co., C. O.
Colorado Iron Works Co.
James Ore Concentrator Co.
Jeffrey Mfg. Co.
Mine & Smelter Supply Co., The
Stephens-Adamson Mfg. Co.
Traylor Engineering & Mfg. Co.

**Filter Cloth**
Filter Fabrics Co.

**Filter Cloth, Metallic**
American Continuous Filter Co. (See United Filters Corp.)
Kelly Filter Press Co. (See United Filters Corp.)
Sweetland Filter Press Co. (See United Filters Corp.)
United Filters Corp.

**Filter Paper**
Denver Fire Clay Co.

**Filter Presses**
Sperry Co., D. R.

**Filters**
Colorado Iron Works Co.
Chicago Pneumatic Tool Co.
Traylor Engineering & Mfg. Co.
United Filters Corp.

**Filters, Concentrate**
Oliver Continuous Filter Co.

**Filters, Cyanide**
Oliver Continuous Filter Co.

**Filters, Water**
Permutit Co., The
Scaife, Wm. B., & Sons Co.,

**Fire Forcing Presses**
Wood & Co., R. D.

**Flange Presses**
Wood & Co., R. D.

**Flanges, Forged Steel Pipe**
American Spiral Pipe Works

**Flood-Lighting Projectors**
Electric Service Supplies Co.

**Flotation Apparatus**
Denver Fire Clay Co.

**Flotation Cell Bottoms, Cloth**
Filter Fabrics Co.

**Flotation Machines**
Butchart, W. A.
Stimpson Equipment Co.

**Fluorspar**
Consolidated M'g & Sm'l'g Co. of Canada, Ltd.

**Flotation Oils**
General Naval Stores Co.
Pensacola Tar & Turpentine Co.

**Forges**
Denver Fire Clay Co.
Foundation Co., The
Ingersoll-Rand Co.
Monarch Eng. & Mfg. Co.

**Forgings, Heavy**
Midvale Steel & Ordnance Co.

**Foundations, Pneumatic Caisson**
Foundation Co., The

**Framers, Timber**
Denver Engineering Works Co.
Dillon-Box Iron Works Co.

**Furnaces, Assay**
Braun Corporation, The
Braun-Knecht-Heimann Co.
Denver Fire Clay Co.
Mine & Smelter Supply Co., The

**Furnaces, Bullion Melting**
Braun Corporation, The
Braun-Knecht-Heimann Co.
Denver Fire Clay Co.
Mine & Smelter Supply Co., The
Monarch Engineering & Mfg. Co.

**Furnaces, Crucible, Tilting and Refining**
Mine & Smelter Supply Co., The
Monarch Engineering & Mfg. Co.

**Furnaces, Crucible, Tilting Metal**
Mine & Smelter Supply Co., The
Monarch Engineering & Mfg. Co

**Furnaces, Electric**
Denver Fire Clay Co.
General Electric Co.

**Furnace Faces and Linings**
Denver Fire Clay Co.

**Furnaces, Heat Treatment**
Denver Fire Clay Co.

**Furnaces, Mechanical Roasting**
Allis-Chalmers Mfg. Co.
Colorado Iron Works Co.
General Chemical Co.
Mine & Smelter Supply Co., The
Morse Bros. Mach. & Supply Co.
Traylor Engineering & Mfg. Co.
Wedge Mechanical Furnace Co.
Worthington Pump & Mchy. Corp.

**Furnaces, Melting**
Denver Fire Clay Co.

**Furnaces, Smelting**
Allis-Chalmers Mfg. Co.
Colorado Iron Works Co.
Morse Bros. Mach. & Supply Co.
Traylor Engineering & Mfg. Co.
Worthington Pump & Mchy. Corp.

**Fuses, Electric**
Westinghouse Electric & Mfg. Co.

**Galvanizing Flux**
Syracuse Smelting Works
United American Metals Corp.

**Gas Producers**
Wood & Co., R. D.

**Gas Purifiers**
Wood & Co., R. D.

**Gas Scrubbers**
Bartlett Hayward Co.

**Gaskets**
Goodrich Co., B. F.

**Gear Cases**
Electric Service Supplies Co.

**Gears**
Denver Engrg. Works Co.
Fawcus Machine Co.
Hindley Gear Co.
Jeffrey Mfg. Co., The
Philadelphia Gear Works
Stephens-Adamson Mfg. Co.

**Gears, Bevel**
Philadelphia Gear Works

**Gears, Cut and Worm**
Cleveland Worm Gear Co.
Hindley Gear Co.

**Gears, Double Helical**
Caldwell & Sons Co., H. W.
Falk Co., The
Fawcus Machine Co.

**Gears, Rawhide**
Philadelphia Gear Works

**Generators, Electric**
Westinghouse Electric & Mfg. Co.

**Glass Blowing**
Denver Fire Clay Co.

**Glassware, Chemical**
Denver Fire Clay Co.

**Gravel Washing Plants**
Stephens-Adamson Mfg. Co.

**Grease Cups**
Lunkenheimer Co., The

**Grinders, Manganoid Pebble**
Jeffrey Mfg. Co., The

**Grinders, Ore**
Braun Corporation, The
Braun-Knecht Heimann Co.
Colorado Iron Works Co.
Kennedy-Van Saun Eng. & Mfg. Corp.
Mine & Smelter Supply Co., The

**Grinders, Sample**
Denver Engineering Works Co.
Mine & Smelter Supply Co., The
Traylor Engineering & Mfg. Co.

**Hangers, Mine**
Electric Service Supplies Co.

**Headframes, Mine**
American Bridge Co.

**Headlights, Incandescent Mine**
Electric Service Supplies Co.

**Heaters, Feed Water**
Alberger Pump & Condenser Co.

**Hoists, Electric**
Allis-Chalmers Mfg. Co.
Chicago Pneumatic Tool Co.
Denver Engineering Works Co.
Dillon-Box Iron Works Co.
English Iron Works Co.
Flory Mfg. Co., S.
Fulton Engine Works
Hendrie & Bolthoff M. & S. Co.
Jeffrey Mfg. Co., The
Lidgerwood Mfg. Co.
Nordberg Mfg. Co.
Ottumwa Iron Works Co.
Traylor Engineering & Mfg. Co.
United Iron Works Co.
Vulcan Iron Works

**Hoists, Gas and Gasoline**
Lidgerwood Mfg. Co.
Novo Engine Co.

**Hoists, Mine Compressed Air**
Lidgerwood Mfg. Co.

**Hoists, Portable**
Hendrie & Bolthoff M. & S. Co.
Ingersoll-Rand Co.
Lidgerwood Mfg. Co.
Mine & Smelter Supply Co., The
Novo Engine Co.

**Hoists, Skip**
Bartlett & Snow Co., C. O.
Lidgerwood Mfg. Co.

**Hoists, Steam**
Allis-Chalmers Mfg. Co.
English Iron Works Co.
Flory Mfg. Co., S.
Goodyear Tire & Rubber Co.
Hendrie & Bolthoff M. & S. Co.
Holmes & Brothers, Inc., Robert
Lidgerwood Mfg. Co.
Mine & Smelter Supply Co., The
Nordberg Mfg. Co.
Ottumwa Iron Works Co.
United Iron Works Co.
Vulcan Iron Works

**Hose, Air**
Denver Rock Drill Mfg. Co.
Diamond Rubber Co., The
Goodrich Co., The B. F.
Goodyear Tire & Rubber Co.
Ingersoll-Rand Co.
United States Rubber Co.

**Hose, Couplings, High Pressure**
Knox Mfg. Co.

**Houses, Steel Shaft**
American Bridge Co.

**Hydraulic Accumulators**
Wood & Co., R. D.

**Idlers, Conveyor**
Conveying Weigher Co., The

**Injectors**
Lunkenheimer Co.

**Instruments, Surveying**
Ainsworth & Sons, Wm.
Berger & Sons Co., C. L.
Buff & Buff Mfg. Co.

**Insulating Materials, Electric**
Electric Service Supplies Co.
Westinghouse Electric & Mfg. Co.

**Iron Removal Apparatus**
Permutit Co.

**Jackets, Water**
Allis-Chalmers Mfg. Co.
Colorado Iron Works Co.
Traylor Engineering & Mfg. Co.

**Jigs**
Allis-Chalmers Mfg. Co.
Colorado Iron Works Co.
Denver Engineering Works Co.
James Ore Concentrator Co.
Mine & Smelter Supply Co., The
Traylor Engineering & Mfg. Co.
Worthington Pump & Mchy. Corp.

**Joints, Expansion**
Alberger Pump & Condenser Co.

**Kilns, Rotary**
Allis-Chalmers Mfg. Co.

**Kilns, Rotary Ore Nodulizers**
Ruggles-Coles Engrg. Co.
Vulcan Iron Works

**Laboratory Machinery**
Braun Corporation, The
Braun-Knecht-Heinmann Co.
Denver Fire Clay Co.
Mine & Smelter Supply Co., The

**Lacing, Leather**
Schieren Co., Charles A.

**Lamps, Acetylene**
Milburn Co., Alex.

**Lamps, Electric**
Edison Storage Battery Co.
Westinghouse Electric & Mfg. Co.

**Lamp Guards**
Edison Storage Battery Co.
Electric Service Supplies Co.
United American Metals Corp.

**Lamps, Safety Cap**
Edison Storage Battery Co.
Westinghouse Electric & Mfg. Co.

**Lead**
American Metal Co.
American Smlg. & Refg. Co.
American Zinc, Lead & Smlg. Co.
Consolidated M'g. & Sm'l'g Co. of Canada, Ltd.
Hardy, Inc., Chas.
St. Joseph Lead Co.
Syracuse Smelting Works
United American Metals Corp.
U. S. Smelting, Refining & Mining Co.

# D.F.C.

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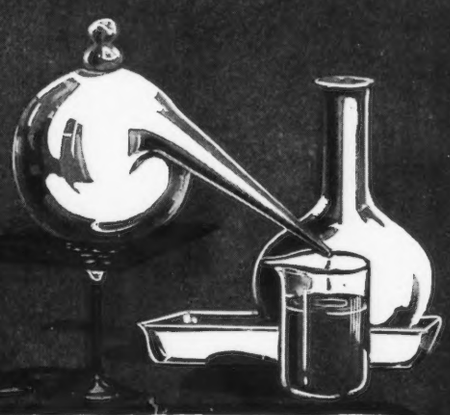

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**Linings, Ball Mill**
Allis-Chalmers Mfg. Co.
Denver Engrg. Works Co.
Traylor Engineering & Mfg. Co.

**Linings, Tube Mill**
Traylor Engineering & Mfg. Co.

**Loading Booms, Adjustable**
Jeffrey Mfg. Co., The

**Loaders, Wagon**
Portable Machinery Co., Inc.

**Locomotives, Compressed Air**
Porter Co., H. K.

**Locomotives, Electric**
General Electric Co.
Jeffrey Mfg. Co., The
Westinghouse Electric & Mfg. Co.

**Locomotives, Electric Storage Battery**
Atlas Car & Mfg. Co.
Edison Storage Battery
General Electric Co.
Jeffrey Mfg. Co., The
Koppel Industrial Car and Equipment Co.
Westinghouse Electric & Mfg. Co.
Whitcomb Co., Geo. D.

**Locomotives, Gasoline**
J. D. Fate Co.
Vulcan Iron Works
Whitcomb Co., Geo. D.

**Locomotives, Industrial**
American Locomotive Co.
J. D. Fate Co.
Jeffrey Mfg. Co., The
Porter Co., H. K.
Whitcomb Co., Geo. D.

**Locomotives, Mine**
American Locomotive Co.
J. D. Fate Co.
Jeffrey Mfg. Co., The
Porter Co., H. K.
Westinghouse Electric & Mfg. Co.
Whitcomb Co., Geo. D.

**Locomotives, Parts**
American Locomotive Co.

**Locomotives, Steam**
American Locomotive Co.
Porter Co., H. K.
Vulcan Iron Works

**Lubricating Oils**
Standard Oil Co.

**Lubricators**
Lunkenheimer Co.

**Magnetic Pulleys**
Dings Magnetic Separator Co.

**Magnets, Electro**
Dings Magnetic Separator Co.

**Magnets, High Intensity**
Dings Magnetic Separator Co.

**Magnets, Standard and Special**
Dings Magnetic Separator Co.

**Mechanical Lubricators**
Lunkenheimer Co.

**Meters, Electric Current**
Westinghouse Electric & Mfg. Co.

**Metals and Alloys**
Leavitt & Co., C. W.
Primos Chemical Co.

**Metals, Noncorrosive**
International Nickel Co., The

**Metals, Perforated**
Allis-Chalmers Mfg. Co.
Harrington & King Perforating Co., The.
Hendrick Mfg. Co.

**Mills, Ball, Tube and Pebble**
Abbe Engineering Co.
Allis-Chalmers Mfg. Co.
Bethlehem Shipbuilding Corp., Ltd.
Chalmers & Williams
Colorado Iron Works Co.
Denver Engineering Works Co.
Hendrie & Bolthoff M. & S. Co.
Herman, John
Mine & Smelter Supply Co., The.
Traylor Engineering & Mfg. Co.
Worthington Pump & Mchy. Corp.

**Mills, Chilean**
Colorado Iron Works Co.
Traylor Engineering & Mfg. Co.

**Mills, Stamp**
Allis-Chalmers Mfg. Co.
Colorado Iron Works Co.
Denver Engineering Works Co.
Hendrie & Bolthoff M. & S. Co.
Traylor Eng. & Mfg. Co.
Worthington Pump & Mchy. Corp.

**Mine Cars, Roller Bearing**
Ottumwa Iron Works Co.

**Mine Hangers & Insulators**
Electric Service Supplies Co.

**Mixers**
Smith Engineering Works

**Molybdenum Ore, Buyers of**
Primos Chemical Co.

**Motors**
Allis-Chalmers Mfg. Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.

**Motor Generator Sets**
General Electric Co.
Westinghouse Electric & Mfg. Co.

**Motor Control**
Westinghouse Electric & Mfg. Co.

**Motor Trucks**
Chicago Pneumatic Tool Co.
White Co.

**Netting, Wire**
Ludlow-Saylor Wire Co.

**Nickel**
Nichols Copper Co.
International Nickel Co., The

**Nudulizers, Ore**
Vulcan Iron Works

**Oil Cups**
Lunkenheimer Co.

**Ore, Buyers and Sellers of**
American Metal Co.
American Smelting & Refining Co.
American Zinc & Chemical Co.
American Zinc, Lead & Smelting Co.
Balbach Smelting & Refining Co.
Bartlesville Zinc Co.
Grasselli Chemical Co.
Greutert Co., H. J.
Hardy, Inc., Charles
Hegeler Zinc Co., The
Illinois Zinc Co., The
International Smelting Co.
Irvington Smelting & Refining Works
Leavitt & Co., C. W.
Matthiessen & Hegeler Zinc Co.
New Jersey Concentrating Co.
Pass & Son, Ltd., Capper
Pennsylvania Smelting Co.
Phelps, Dodge Corp.
St. Joseph Lead Co.
Societe "Minerais and Metaux"
Stork & Co., Inc., Chas. T.
United Metals Selling Co.
United States Smelting, Refining & Mining Co.
Vernon Metal & Produce Co.
Virginia Smelting Co.
Vogelstein & Co., L.
Western Zinc Concentrating Co.
White & Bro.

**Ore Concentrators**
New Jersey Concentrating Co.

**Ores, Rare**
Willmarth O., Barlow

**Ore, Sampling**
Beach & Co.
Ledoux & Co., Inc.
Pitkin, Inc., Lucius

**Overhead Line Material**
Electric Service Supplies Co.

**Oxy-Acetylene and Oxy-Hydrogen Apparatus**
Davis-Bournonville Co.
Milburn Co., Alex.

**Packing**
The Diamond Rubber Co.
Garlock Packing Co.
Goodrich Co., The B. F.
Goodyear Tire & Rubber Co.
Jenkins Bros.
United States Rubber Co.

**Packing, Hydraulic**
Schieren Co., Charles A.

**Packing, Rod**
United States Rubber Co.

**Packing Sheet**
United States Rubber Co.

**Paints, Preservative**
Parrafine Companies, Inc., The

**Pebbles, Grinding**
Wood & Co., R. D.

**Perforated Metals**
(See Metals, Perforated)

**Phosphor Copper**
Syracuse Smelting Works
United American Metals Corp.

**Phosphor Tin**
Syracuse Smelting Works
United American Metals Corp.

**Pipe and Resisting**
U. S. Cast Iron Pipe & Fdy. Co.

**Pipe, Air Line**
National Tube Co.

**Pipe, Cast Iron**
Cast Iron Pipe Publicity Bureau
U. S. Cast Iron Pipe & Fdy. Co.

**Pipe Fittings, Bronze**
Lunkenheimer Co.

**Pipe, Spiral Riveted**
Abendroth & Root Mfg. Co.
American Spiral Pipe Works

**Pipe, Steel**
Caldwell Co., Inc., W. E.
National Tube Co.

**Pipe, Steel Welded**
American Spiral Pipe Works

**Pipe, Wood**
Caldwell Co., Inc., W. E.
National Tank & Pipe Co.
Pacific Tank & Pipe Co.
Redwood Mfrs. Co.

**Pipe, Wrought-Iron**
Byers Co., A. M.

**Platinum**
Baker & Co., Inc.
Bishop & Co. Platinum Works, J.

**Pneumatic Tools**
Ingersoll-Rand Co.

**Pneumatic Tie Tampers**
Ingersoll-Rand Co.

**Powder, Blasting**
Aetna Explosives Co.
Atlas Powder Co.
Grasselli Chemical Co.

**Power Plants**
Foundation Co., The

**Power Transmission Machinery**
Caldwell & Sons Co., H. W.
Smith Co., S. Morgan
Stephens-Adamson Mfg. Co.
Traylor Engineering & Mfg. Co.

**Preservative, Pipe**
Highland Chemical Products Co.

**Pressers, Filter**
American Continuous Filter Corp.
(See United Filters Corp.)
Kelly Filter Press Co.
(See United Filters Corp.)
Shriver & Co., T.
Sweetland Filter Press Co.
(See United Filters Corp.)
United Filters Corp.
Worthington Pump & Mchy. Corp.

**Presses, Hydraulic**
Wood & Co., R. D.

**Publishers, Technical**
McGraw-Hill Book Co.
Wiley & Sons, Inc., John

**Pulleys, Magnetic**
Cutler-Hammer Mfg. Co.
Dings Magnetic Separator Co.

**Pulverizers, Coal**
Jeffrey Mfg. Co., The
Traylor Engineering & Mfg. Co.

**Pulverizers, Ore**
Braun Corporation, The
Braun-Knecht Heimann Co.
Colorado Iron Works Co.
Jeffrey Mfg. Co.
Mine & Smelter Supply Co., The
Traylor Engineering & Mfg. Co.

**Pumping Engines**
Allis-Chalmers Mfg. Co.

**Pumps, Boiler Feed**
Cameron Steam Pump Wks., A. S.
Worthington Pump & Mchy. Corp.

**Pumps, Centrifugal**
Alberger Pump & Condenser Co.
Cameron Steam Pump Wks., A. S.
De Laval Steam Turbine Co.
Krogh Pump Mfg. Co.
Mine & Smelter Supply Co., The
Morris Machine Works
Novo Engine Co.
Oliver Continuous Filter Co.
Wood & Co., R. D.
Worthington Pump & Mchy. Corp.

**Pumps, Deep Well**
Cameron Steam Pump Wks., A. S.
Novo Engine Co.
United Iron Works Co.

**Pumps, Electric**
Alberger Pump & Condenser Co.
Cameron Steam Pump Wks., A. S.
Hendrie & Bolthoff M. & S. Co.
Krogh Pump Mfg. Co.
Oliver Continuous Filter Co.
Roots Co., P. H. & F M
Taber Pump Co.

**Pumps, Mill**
Cameron Steam Pump Wks., A. S.
Colorado Iron Works Co.
Frenier & Son, J. H.
Krogh Pump Mfg. Co.
Morris Machine Works
Oliver Continuous Filter Co.
Roots Co., P. H. & F. M.
Taber Pump Co.
Traylor Engineering & Mfg. Co.

**Pumps, Mine**
Alberger Pump & Condenser Co.
Allis-Chalmers Mfg. Co.
Cameron Steam Pump Wks., A. S.
Hendrie & Bolthoff M. & S. Co.
Krogh Pump Mfg. Co.
Mine & Smelter Supply Co., The
Morris Machine Works
Taber Pump Co.
United Iron Works Co.
Wood & Co., R. D.
Worthington Pump & Mchy. Corp.

**Pumps, Pneumatic Air Lift**
Sullivan Machinery Co.

**Pumps, Power Plant**
Alberger Pump & Condenser Co.
Cameron Steam Pump Wks., A. S.
Roots Co., P. H. & F. M.
Worthington Pump & Mchry. Corp.

**Pumps, Sand, Slime and Tailings**
Colorado Iron Works Co.
Dorr Co., The
Frenier & Son, J. H.
Krogh Pump Mfg. Co.
Traylor Engineering & Mfg. Co
Worthington Pump & Mchy. Corp.

**Pumps, Sinking**
Cameron Steam Pump Wks., A. S.
Krogh Pump Mfg. Co.
Worthington Pump & Mchy. Corp.

**Pumps, Vacuum**
Abbe Engineering Co.
Cameron Steam Pump Wks., A. S.
Chicago Pneumatic Tool Co.
Colorado Iron Works Co.
Ingersoll-Rand Co.
Oliver Continuous Filter Co.
Roots Co., P. H. & F. M.

**Punches, Hydraulic**
Wood & Co., R. D.

**Rail Bonding Tools**
Electric Service Supplies Co.

**Rail Bonds**
Electric Service Supplies Co.

**Refractories**
Harbison-Walker Refractories Co.

**Reproducer, Photographic**
Commercial Camera Co.

**Respirators**
Goodrich Co., The B. F.

**Rheostats, Liquid**
Westinghouse El. & Mfg. Co.

**Riddles, Wire**
Ludlow-Saylor Wire Co.

**Riveters, Hydraulic**
Wood & Co., R. D.

**Roasters, Ore**
Colorado Iron Works Co.
Ruggles-Coles Eng'r'g. Co.
Vulcan Iron Works Co.

**Roofing, Sheet Steel**
American Sheet & Tin Plate Co.

**Roll Shells**
Midvale Steel & Ordnance Co.

**Roller Bearings for Car Wheels**
Enterprise Fdry. & Machine Co.

**Rolls, Crushing** (See "Crushers")

**Rope, Manila and Sisal**
Waterbury Co.

**Rope, Rawhide**
Schieren Co., Charles A.

**Rope, Wire**
Leschen & Sons Rope Co., A.
Moon Co., Geo. C.
Roebling's Sons Co., John A.
Waterbury Co.

**Rules, Measuring**
Lufkin Rule Co

**Safety Caps**
Edison Storage Battery Co.

**Samplers, Ore**
Allis-Chalmers Mfg. Co.
Braun Corporation, The
Braun-Knecht-Heimann Co.
Colorado Iron Works Co.
Denver Engineering Works Co.
Hendrie & Bolthoff M. & S. Co.
Mine & Smelter Supply Co., The
Ricketts & Co., Inc.
Traylor Engineering & Mfg. Co.
Worthington Pump & Mchy. Corp.

**Screening Plants**
Bartlett Hayward Co., The

**Screens**
Allis-Chalmers Mfg. Co.
Butchart, W. A.
Colorado Iron Works Co.
James Ore Concentrating Co.
Jeffrey Mfg. Co., The
Mine & Smelter Supply Co., The
Stephens-Adamson Mfg. Co.
Traylor Engineering & Mfg. Co.

**Screen, Perforated Metal**
Allis-Chalmers Mfg. Co.
Chicago Perforating Co.
Harrington & King Perforating Co., The
Hendrick Mfg. Co.

**Screen Plates for Gold Dredges**
Bethlehem Shipbuilding Corp., Ltd.

**Screens, Incline, Vibratory**
Colorado Iron Works Co.
Jeffrey Mfg. Co., The

**Screens, Revolving**
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Denver Engrg. Works Co.
Harrington & King Perforating Co., The
Hendrie & Bolthoff M. & S. Co.
Jeffrey Mfg. Co., The
Ludlow-Saylor Wire Co.
Stephens-Adamson Mfg. Co.
Traylor Engineering & Mfg. Co.
United Iron Wks. Co.
Worthington Pump & Mchy. Corp.

**Screens, Rolled Slot**
Ludlow Saylor Wire Co.

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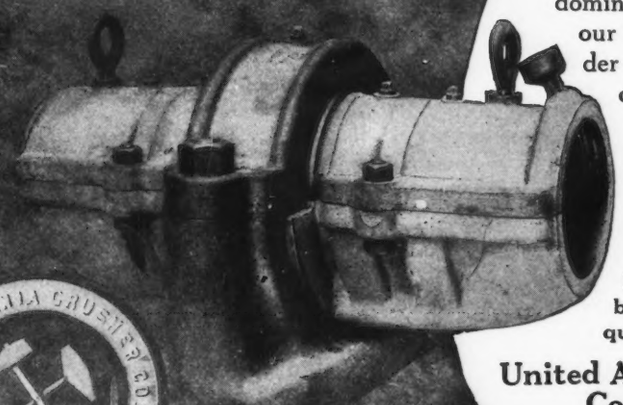

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Zinc
Lead
Aluminum
Tin
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Nickel

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AND
LOWERS COSTS

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Shaft and Tunnel Contracting and Consulting Engineers
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(See Searchlight Section)
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Duquesne Electric & Mfg. Co.
Gregory Electric Co.
Morse Bros. Mach. & Supply Co.
MacGovern & Co., 114 Liberty St.
Zelnicker Supply Co., Walter A.

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Nichols Copper Co.

**Separators, Magnetic**
Buchanan Co., Inc., C. G.
Cutler-Hammer Mfg. Co.
Dings Magnetic Separator Co.

**Separators, Magnetic Wet**
Dings Magnetic Separator Co.

**Shaft Sinking**
Fitch, Jr., Walter

**Shafts, Reinforced Concrete**
Foundation Co., The

**Sharpeners, Drill**
Denver Rock Drill Mfg. Co.
Ingersoll-Rand Co.
Sullivan Machinery Co.

**Shears, Hydraulic**
Wood & Co., R. D.

**Sheet Iron Work**
Hendrick Mfg. Co.

**Sheet Steel, Black and Galvanized**
American Sheet & Tin Plate Co.

**Shovels, Electric**
Marion Steam Shovel Co.

**Shovels, Hand**
Conneaut Shovel Co.
Wyoming Shovel Co.

**Shovels, Power**
Thew Automatic Shovel Co.

**Shovels, Steam, Gas & Electric**
Marion Steam Shovel Co.
Thew Automatic Shovel Co.

**Signs, Electric**
Federal Sign Co.

**Sirens, Electric**
Federal Sign Co.

**Skips**
Allis-Chalmers Mfg. Co.
Denver Engrg. Works Co.
Sanford-Day Iron Co.
Traylor Engineering & Mfg. Co.

**Skip Hoists**
Jeffrey Mfg. Co., The

**Smelters**
American Smelting & Refining Co.
American Zinc, Lead & Smelting Co.
Balbach Smelting & Refining Co.
Grasselli Chemical Co.
Illinois Zinc Co.
International Smelting Co.
Matthiessen & Hegeler Zinc Co.
Nichols Copper Co.
United States Smelting, Refining & Mining Co.
Vogelstein & Co., L.

**Sockets, Electric**
Cutler-Hammer Mfg. Co.

**Sockets, Electric Lamp**
Cutler-Hammer Mfg. Co.

**Solders**
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Syracuse Smelting Works
United American Metals Corp.

**Spades**
Conneaut Shovel Co.
Wyoming Shovel Works

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American Smlg. & Refg. Co.
American Zinc, Lead & Smlg. Co.
Consolidated M'g & Sm'l'g Co. of Canada, Ltd.
Grasselli Chemical Co.
Syracuse Smelting Works
United American Metals Corp.
U. S. Smelting, Refining & Mining Co.

**Spouts, Magnetic**
Dings Magnetic Separator Co.

**Steam and Hydraulic Forging Presses**
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Colonial Steel Co.
Halcomb & Davidson, Inc.
Ingersoll-Rand Co.
International High Speed Steel Co.
Midvale Steel & Ordnance Co.
Milne & Co., A.

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**Steels, Special**
International High Speed Steel Co.

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National Tube Co.

**Stokers, Mechanical**
Westinghouse Electric & Mfg. Co.

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Edison Storage Battery Co.

**Strands, Stone Sawing**
Moon Co., Geo. C.

**Sulphur Removal Apparatus**
Permutit Co.

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General Electric Co.
Hendrie & Bolthoff, M. & S. Co.
Westinghouse Electric & Mfg. Co.

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National Tube Co.

**Tanks, Steel**
Bartlett Hayward Co.
Caldwell Co., Inc., W. E.

**Tanks, Wood**
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Mine & Smelter Supply Co., The
Pacific Tank & Pipe Co.
Redwood Mfrs. Co.

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Lufkin Rule Co.

**Telephones, Mine**
Electric Service Supplies Co.
Stromberg-Carlson Telephone Mfg. Co.

**Thickeners**
Dorr Co., The

**Threaders and Cutters, Pipe**
Armstrong Mfg. Co.

**Timbers, Steel Shaft**
American Bridge Co.

**Tin**
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United American Metals Corp.

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**Tool Steel**
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**Tractors**
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Electric Service Supplies Co.

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Leavitt & Co., C. W., Inc.
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Primos Chemical Co.

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Fitch, Jr., Walter

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Smith Co., S. Morgan

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De Laval Steam Turbine Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.

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Allis-Chalmers Mfg. Co.

**Turbine Water Wheels**
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Lunkenheimer Co., The
Wood & Co., R. D.

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National Tube Co.
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**Valves, Pump**
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Primos Chemical Co.

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Lunkenheimer Co.

**Water Rectification**
Permutit Co.

**Water Softeners**
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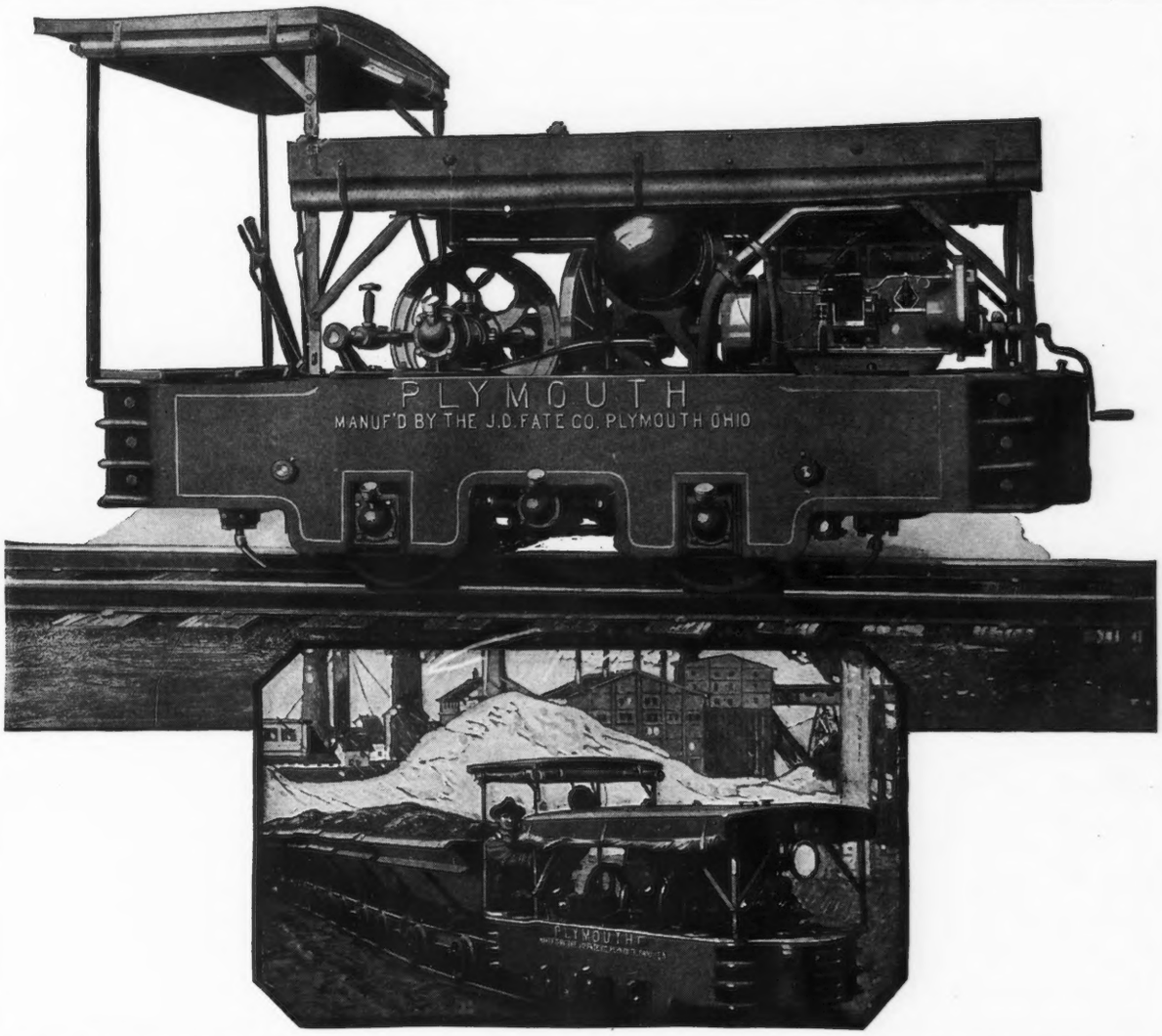


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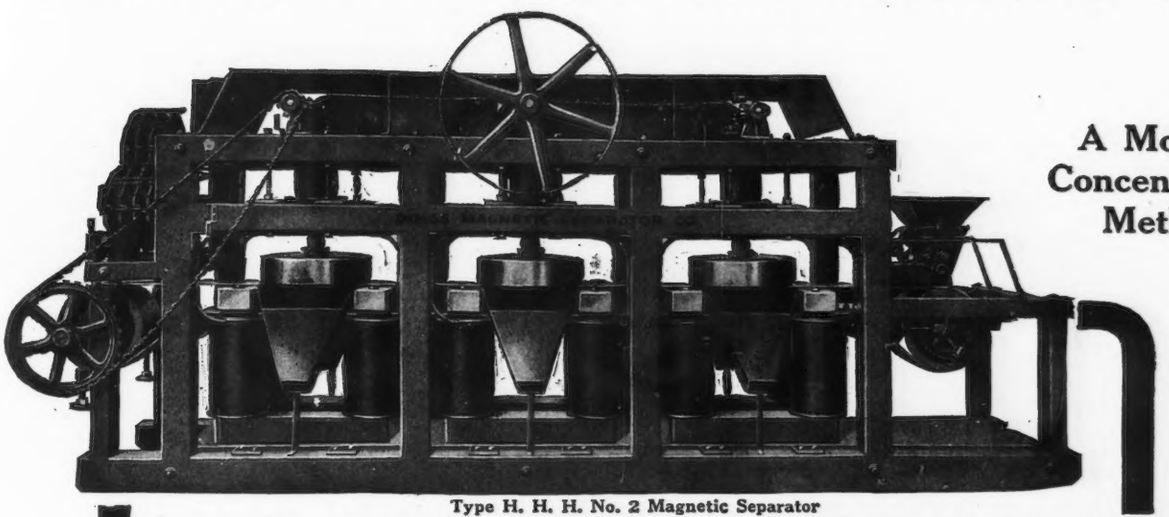

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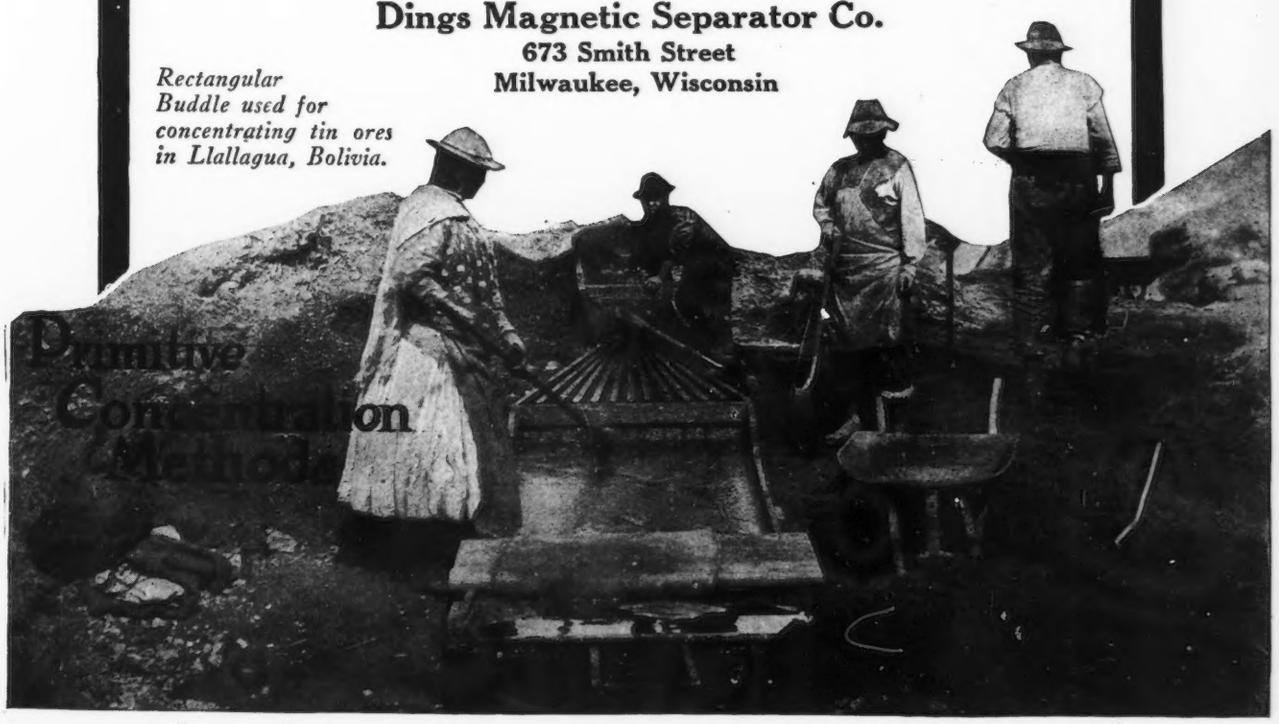

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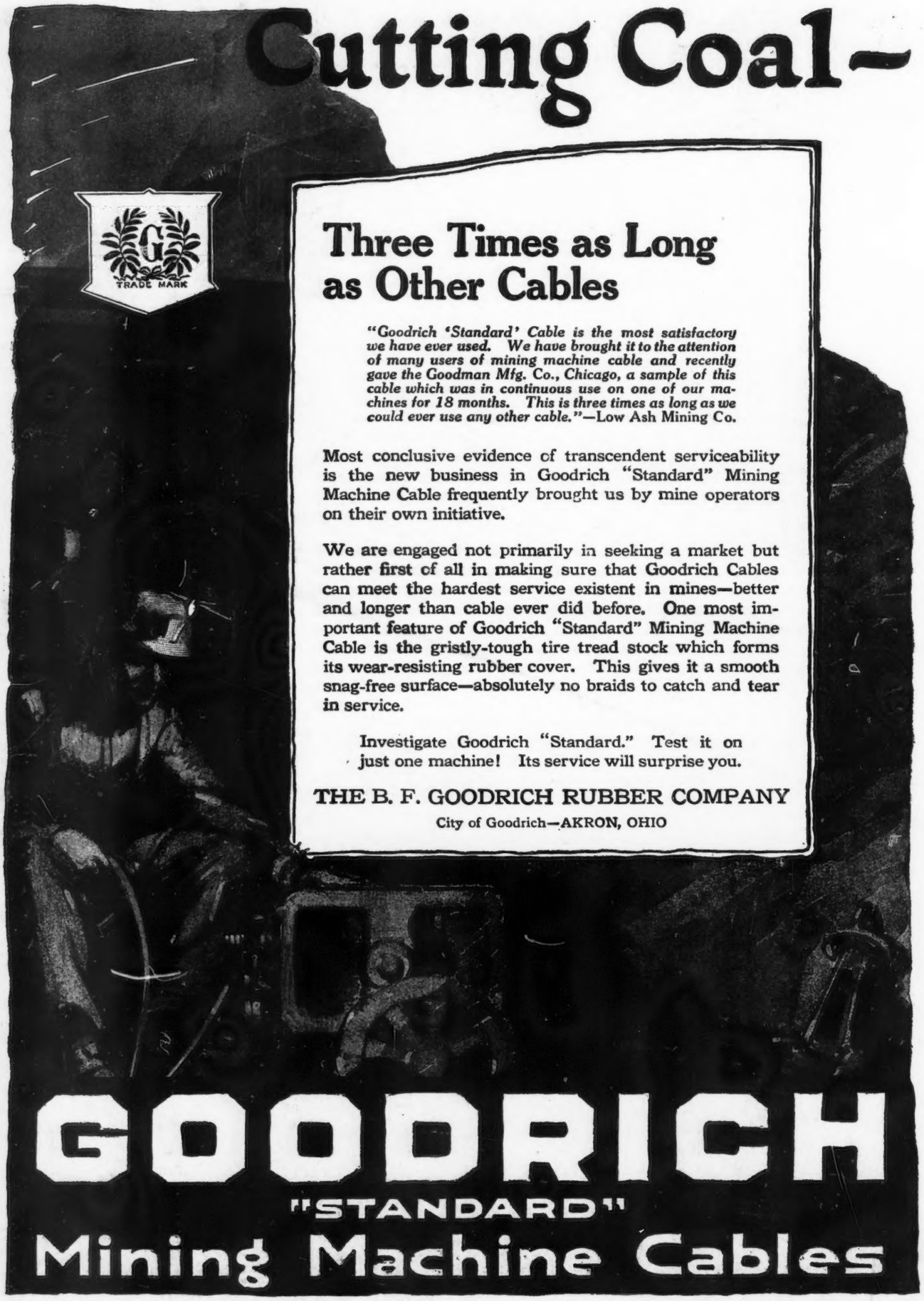

## Three Times as Long as Other Cables

*"Goodrich 'Standard' Cable is the most satisfactory we have ever used. We have brought it to the attention of many users of mining machine cable and recently gave the Goodman Mfg. Co., Chicago, a sample of this cable which was in continuous use on one of our machines for 18 months. This is three times as long as we could ever use any other cable."*—Low Ash Mining Co.

Most conclusive evidence of transcendent serviceability is the new business in Goodrich "Standard" Mining Machine Cable frequently brought us by mine operators on their own initiative.

We are engaged not primarily in seeking a market but rather first of all in making sure that Goodrich Cables can meet the hardest service existent in mines—better and longer than cable ever did before. One most important feature of Goodrich "Standard" Mining Machine Cable is the gristly-tough tire tread stock which forms its wear-resisting rubber cover. This gives it a smooth snag-free surface—absolutely no braids to catch and tear in service.

Investigate Goodrich "Standard." Test it on just one machine! Its service will surprise you.

**THE B. F. GOODRICH RUBBER COMPANY**

City of Goodrich—AKRON, OHIO

# GOODRICH

"STANDARD"

Mining Machine Cables